



# ANTIMICROBIAL RESISTANCE

Global Report  
on surveillance

2014



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Global Report  
on surveillance

*2014*



World Health  
Organization

#### **WHO Library Cataloguing-in-Publication Data**

#### **Antimicrobial resistance: global report on surveillance.**

1.Anti-infective agents - classification. 2.Anti-infective agents - adverse effects. 3.Drug resistance, microbial - drug effects. 4.Risk management. 5.Humans. I.World Health Organization.

ISBN 978 92 4 156474 8

(NLM classification: QV 250)

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Design and Layout: [www.paprika-annecy.com](http://www.paprika-annecy.com)

Printed in France

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# Foreword

Antimicrobial resistance (AMR) within a wide range of infectious agents is a growing public health threat of broad concern to countries and multiple sectors. Increasingly, governments around the world are beginning to pay attention to a problem so serious that it threatens the achievements of modern medicine. A post-antibiotic era—in which common infections and minor injuries can kill—far from being an apocalyptic fantasy, is instead a very real possibility for the 21<sup>st</sup> century.

Determining the scope of the problem is essential for formulating and monitoring an effective response to AMR. This WHO report, produced in collaboration with Member States and other partners, provides as accurate a picture as is presently possible of the magnitude of AMR and the current state of surveillance globally.

The report focuses on antibacterial resistance (ABR) in common bacterial pathogens. Why? There is a major gap in knowledge about the magnitude of this problem and such information is needed to guide urgent public health actions. ABR is complex and multidimensional. It involves a range of resistance mechanisms affecting an ever-widening range of bacteria, most of which can cause a wide spectrum of diseases in humans and animals.

One important finding of the report, which will serve as a baseline to measure future progress, is that there are many gaps in information on pathogens of major public health importance. In addition, surveillance of ABR generally is neither coordinated nor harmonized, compromising the ability to assess and monitor the situation.

Nonetheless, the report makes a clear case that resistance to common bacteria has reached alarming levels in many parts of the world indicating that many of the available treatment options for common infections in some settings are becoming ineffective. Furthermore, systematic reviews of the scientific evidence show that ABR has a negative impact on outcomes for patients and health-care expenditures.

Generally, surveillance in TB, malaria and HIV to detect resistance, determine disease burden and monitor public health interventions is better established and experiences from these programmes are described in the report, so that lessons learnt can be applied to ABR and opportunities for collaboration identified.

WHO, along with partners across many sectors, is developing a global action plan to mitigate AMR. Strengthening global AMR surveillance will be a critical aspect of such planning as it is the basis for informing global strategies, monitoring the effectiveness of public health interventions and detecting new trends and threats.



**Dr Keiji Fukuda**  
Assistant Director-General  
Health Security

# Summary

Antimicrobial resistance (AMR) threatens the effective prevention and treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi. This report examines, for the first time, the current status of surveillance and information on AMR, in particular antibacterial resistance (ABR), at country level worldwide.

## Key findings and public health implications of ABR are:

- Very high rates of resistance have been observed in bacteria that cause common health-care associated and community-acquired infections (e.g. urinary tract infection, pneumonia) in all WHO regions.
- There are significant gaps in surveillance, and a lack of standards for methodology, data sharing and coordination.

Key findings from AMR surveillance in disease-specific programmes are as follows:

- Although multidrug-resistant TB is a growing concern, it is largely under-reported, compromising control efforts.
- Foci of artemisinin resistance in malaria have been identified in a few countries. Further spread, or emergence in other regions, of artemisinin-resistant strains could jeopardize important recent gains in malaria control.
- Increasing levels of transmitted anti-HIV drug resistance have been detected among patients starting antiretroviral treatment.

## Surveillance of ABR and sources of data

There is at present no global consensus on methodology and data collection for ABR surveillance. Routine surveillance in most countries is often based on samples taken from patients with severe infections – particularly infections associated with health care, and those in which first-line treatment has failed. Community-acquired infections are almost certainly underrepresented among samples, leading to gaps in coverage of important patient groups.

Nevertheless, it is critical to obtain a broad picture of the international scope of the problem of ABR. To accomplish this, WHO obtained, from 129 Member States, the most recent information on resistance surveillance and data for a selected set of nine bacteria–antibacterial drug combinations of public health importance. Of these, 114 provided data for at least one of the nine combinations (22 countries provided data on all nine combinations).

Some data sets came from individual surveillance sites, or data from several sources rather than national reports. Many data sets were based on a small number of tested isolates of each bacterium (<30), adding to uncertainty about the precision of the data; this reflects a lack of national structures to provide an overview of the situation and limited capacity for timely information sharing. Most data sets, individual sites or aggregated data, were based on hospital data. Non-representativeness of surveillance data is a limitation for the interpretation and comparison of results.

The data compiled from countries indicate where there may be gaps in knowledge and lack of capacity to collect national data. Among WHO regions, the greatest country-level data were obtained from the European Region and the Region of the Americas, where long-standing regional surveillance and collaboration exist.

## Current status of resistance in selected bacteria

In the survey forming the basis for this part of the report, information was requested on resistance to antibacterial drugs commonly used to treat infections caused by nine bacteria of international concern. The chosen bacteria are causing some of the most common infections in different settings; in the community, in hospitals or transmitted through the food chain. The main findings are summarized in the following tables:

### Bacteria commonly causing infections in hospitals and in the community

| Name of bacterium/<br>resistance                                                                               | Examples of typical<br>diseases                                    | No. out of 194 Member<br>States providing data | No. of WHO regions<br>with national reports of<br>50% resistance or more |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------|
| <i>Escherichia coli</i> /<br>- vs 3 <sup>rd</sup> gen. cephalosporins<br>- vs fluoroquinolones                 | Urinary tract infections, blood<br>stream infections               | 86<br>92                                       | 5/6<br>5/6                                                               |
| <i>Klebsiella pneumoniae</i> /<br>- vs 3 <sup>rd</sup> gen. cephalosporins<br>- vs 3 <sup>rd</sup> carbapenems | Pneumonia, blood stream<br>infections, urinary tract<br>infections | 87<br>71                                       | 6/6<br>2/6                                                               |
| <i>Staphylococcus aureus</i> /<br>- vs methicillin "MRSA"                                                      | Wound infections, blood<br>stream infections                       | 85                                             | 5/6                                                                      |

### Bacteria mainly causing infections in the community

| Name of bacterium/<br>resistance                                                     | Examples of typical<br>diseases                 | No. out of 194 Member<br>States providing data | No. of WHO regions<br>with national reports of<br>25% resistance or more |
|--------------------------------------------------------------------------------------|-------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------|
| <i>Streptococcus pneumoniae</i> /<br>- non-susceptible or resistant<br>to penicillin | Pneumonia, meningitis, otitis                   | 67                                             | 6/6                                                                      |
| <i>Nontyphoidal Salmonella</i> /<br>- vs fluoroquinolones                            | Foodborne diarrhoea,<br>blood stream infections | 68                                             | 3/6                                                                      |
| <i>Shigella species</i> /<br>- vs fluoroquinolones                                   | Diarrhoea ("bacillary<br>dysentery")            | 35                                             | 2/6                                                                      |
| <i>Neisseria gonorrhoea</i> /<br>- vs 3 <sup>rd</sup> gen. cephalosporins            | Gonorrhoea                                      | 42                                             | 3/6                                                                      |

The high proportions of resistance to 3<sup>rd</sup> generation cephalosporins reported for *E. coli* and *K. pneumoniae* means that treatment of severe infections likely to be caused by these bacteria in many settings must rely on carbapenems, the last-resort to treat severe community and hospital acquired infections. These antibacterials are more expensive, may not be available in resource-constrained settings, and are also likely to further accelerate development of resistance. Of great concern is the fact that *K. pneumoniae* resistant also to carbapenems has been identified in most of the countries that provided data, with proportions of resistance up to 54% reported. The large gaps in knowledge of the situation in many parts of the world further add to this concern. For *E. coli*, the high reported resistance to fluoroquinolones means limitations to available oral treatment for conditions which are common in the community, such as urinary tract infections.

High rates of MRSA imply that treatment for suspected or verified severe *S. aureus* infections, such as common skin and wound infections, must rely on second-line drugs in many countries, and that standard prophylaxis with first-line drugs for orthopaedic and other surgical procedures will have limited effect in

many settings. Second-line drugs for *S. aureus* are more expensive; also, they have severe side-effects for which monitoring during treatment is advisable, increasing costs even further.

Reduced susceptibility to penicillin was detected in *S. pneumoniae* in all WHO regions, and exceeded 50% in some reports. The extent of the problem and its impact on patients is not completely clear because of variation in how the reduced susceptibility or resistance to penicillin is reported, and limited comparability of laboratory standards. Because invasive pneumococcal disease (e.g. pneumonia and meningitis) is a common and serious disease in children and elderly people, better monitoring of this resistance is urgently needed.

The resistance to fluoroquinolones among two of the major causes for bacterial diarrhoea, nontyphoidal *Salmonella* (NTS) and *Shigella species* were comparatively lower than in *E. coli*. However, there were considerable gaps in information on these two bacteria, particularly from areas where they are of major public health importance. Some reports of high resistance in NTS are of great concern because resistant strains have been associated with worse patient outcomes.

In *N. gonorrhoeae*, finally, decreased susceptibility to third-generation cephalosporins, the treatment of last resort for gonorrhoea, has been verified in 36 countries and is a growing problem. Surveillance is of poor quality in countries with high disease rates, where there is also a lack of reliable resistance data for gonorrhoea, and where the extent of spread of resistant gonococci may be high.

## Health and economic burden due to ABR

Evidence related to the health and economic burden due to ABR in infections caused by *E. coli*, *K. pneumoniae* and MRSA was examined through systematic reviews of the scientific literature. Patients with infections caused by bacteria resistant to a specific antibacterial drug generally have an increased risk of worse clinical outcomes and death, and consume more health-care resources, than patients infected with the same bacteria not demonstrating the resistance pattern in question. Available data are insufficient to estimate the wider societal impact and economic implications when effective treatment for an infection is completely lost as a result of resistance to all available drugs.

## AMR in disease-specific programmes

### Tuberculosis

Globally, 3.6% of new TB cases and 20.2% of previously treated cases are estimated to have multidrug-resistant TB (MDR-TB), with much higher rates in Eastern Europe and central Asia. Despite recent progress in the detection and treatment of MDR-TB, the 84 000 cases of MDR-TB notified to WHO in 2012 represented only about 21% of the MDR-TB cases estimated to have emerged in the world that year. Among MDR-TB patients who started treatment in 2010, only 48% (range 46%–56% across WHO regions) were cured after completion of treatment (with 25% lost to follow-up). The treatment success rate was lower among extensively drug-resistant (XDR-TB) cases.

### Malaria

Surveillance of antimalarial drug efficacy is critical for the early detection of antimalarial drug resistance, because resistance cannot be detected with routine laboratory procedures. Foci of either suspected or confirmed artemisinin resistance have been identified in Cambodia, Myanmar, Thailand and Viet Nam. Further spread of artemisinin-resistant strains, or the independent emergence of artemisinin resistance in other regions, could jeopardize important recent gains in malaria control.

## HIV

HIV drug resistance is strongly associated with failure to achieve suppression of viral replication and thus with increased risk for disease progression. Data collected between 2004 and 2010 in low- and middle-income countries showed increasing levels of transmitted anti-HIV drug resistance among those starting antiretroviral treatment (ART). Available data suggest that 10%–17% of patients without prior ART in Australia, Europe, Japan and the United States of America (USA) are infected with virus resistant to at least one antiretroviral drug.

## Influenza

Over the past 10 years, antiviral drugs have become important tools for treatment of epidemic and pandemic influenza, and several countries have developed national guidance on their use and have stockpiled the drugs for pandemic preparedness. However, widespread resistance to adamantanes in currently circulating A(H1N1) and A(H3N2) viruses have left neuraminidase inhibitors as the antiviral agents recommended for influenza prevention and treatment. Although the frequency of oseltamivir resistance in currently circulating A(H1N1)pdm09 viruses is low (1%–2%), the emergence and rapid global spread in 2007/2008 of oseltamivir resistance in the former seasonal A(H1N1) viruses has increased the need for global antiviral resistance surveillance.

## AMR in other related areas

### Antibacterial resistance in food-producing animals and the food chain

Major gaps exist in surveillance and data sharing related to the emergence of ABR in foodborne bacteria and its potential impact on both animal and human health. Surveillance is hampered by a lack of harmonized global standards. The multisectoral approach needed to contain ABR includes improved integrated surveillance of ABR in bacteria carried by food-producing animals and in the food chain, and prompt sharing of data. Integrated surveillance systems would enable comparison of data from food-producing animals, food products and humans.

### Resistance in systemic candidiasis

Systemic candidiasis is a common fungal infection worldwide and associated with high rates of morbidity and mortality in certain groups of patients. Although it is known that antifungal resistance imposes a substantial burden on health-care systems in industrialized

countries, the global burden of antifungal-resistant *Candida* is unknown. Resistance to fluconazole, a common antifungal drug, varies widely by country and species. Resistance to the newest class of antifungal agents, the echinocandins, is already emerging in some countries.

## Next steps

This report shows major gaps in ABR surveillance, and the urgent need to strengthen collaboration on global AMR surveillance. WHO will therefore facilitate:

- development of tools and standards for harmonized surveillance of ABR in humans, and for integrating that surveillance with surveillance of ABR in food-producing animals and the food chain;
- elaboration of strategies for population-based surveillance of AMR and its health and economic impact; and

- collaboration between AMR surveillance networks and centres to create or strengthen coordinated regional and global surveillance.

AMR is a global health security threat that requires concerted cross-sectional action by governments and society as a whole. Surveillance that generates reliable data is the essential basis of sound global strategies and public health actions to contain AMR, and is urgently needed around the world.

# Acknowledgements

We wish to acknowledge staff in all sites performing resistance surveillance; the aggregated results from this surveillance have formed the basis for the report, without which the report would not have been possible.

## Collecting and compiling data for this report

Abubakar Abdinasir, David Agyapong, Norazah Ahmad, Yacoub Ould Ahmedou, Arjana Tambic Andrasevic, Honoré Bankole, Christina Bareja, Raquel de Bolaños, Michael Borg, Golubinka Bosevska, Mina Brajovic, Eka Buadromo, Lula Budiak, Manuela Caniça, Celia Carlos, Rosa Sacsquispe Contreras, Francis Kasolo, Paul Chun Soo, Silviu Ciobanu, Bruno Coignard, Alex Costa, Robert Cunney, Mbary Daba, Nicole Makaya Dangu, Sabine De Greeff, Nerisse Dominguez, Gabriela El Belazi, Mona El-Shokry, Ian Fisher, Belen Aracil Garcia, Eikhan Gasimov, Gayane Ghukasyan, Matt Goossens, Gilbert Guifar, Lincoln Charimari Gwinji, Antti Hakanen, Helen Heffernan, Ole Heuer, Masoumi Asl Hossein, Simsek Husnive, Marina Ivanova, Aurelia Juncq-Attal, Vladimir Jakubu, Al Saman Mohammed Redha Jameela, Carolina Janson, Zora Jelesic, Atek Kagirita, Agha Khaldoun, Baktygul Kambaralieva, Todor Kantardjev, Lonkululeko Khumalo, Lisa Kohler, Yonwoon Kook, Karl Kristinsson, Andreas Kronenberg, Paul Lalita, Kyunwon Lee, Young-Seon Lee, Barbro Liljequist, Eltaib Lina, Jorge Matheu, Jolanta Miciuleviciene, Kentse Moakofhi, Márta Melles, Serifo Meoteiro, Vasil Milo, Li Mingzhou, Issack Mohammad, Dominique Monnet, Karen Nahapetyan, Saskia Nahrgang, Prenesh Naicker, Jarour Hamed Najwa, Christine Ndjabera, Ines Noll, Manuel Neyra, Milan Nikš, Stefan Schytte Olsen, Fandi Osman, Emile Ouedraogo, Annalisa Pantosti, Boris Pavlin, Monique Perrin-Weniger, Uili Peseta, Despo Pieridou-Bagatzouni, Abdur Rashid, Grace E. B. Saguti, Aboubacar Savane, Rasmané Semde, Roxana Serban, Keigo Shibayama, Noikaseumsy Sithivong, Peter Ngalama Songolo, Gianfranco Spiteri, Jeremy Sobel, Al Busaidy Mohamed Suleiman, Johanna Takkinen, Maha Talaat, Israel Tareke, Seth Theoty, Jens Thomsen, Leonid Titov, Teweia Toatu, Sok Touch, Marija Trkov, Litia Tudravu, Marita Van de Laar, Alkiviadis Vatopoulos, Sirenda Vong, Haruro Watanabe, Nicole Werner-Keiss, Therese Westrell, Zhang Xiaxing, Xiao Yonghong, Dorota Zabicka, Khatuna Zakhshvili, Sekesai Zinyowera, Frank Zongo.

We also acknowledge additional contributors, focal points and coordinators not listed above providing data for the surveillance networks coordinated by the ECDC (European Centre for Disease Prevention and Control) – EARS-Net (European Antimicrobial Resistance Surveillance Network), FWD-Net (Foodborne and Waterborne Diseases and Zoonoses Network) and EURO-GASP (the European Gonococcal Antimicrobial Surveillance Programme).

The following institutions participating in the networks coordinated by PAHO/AMRO (Pan American Health Organization/WHO Regional Office for the Americas) – ReLAVRA (Latin American Antimicrobial Resistance Surveillance Network) and SIREVA (Sistema de Redes de Vigilancia de los Agentes Responsables de Neumonías y Meningitis Bacterianas) – Carlos G. Malbrán, ANLIS INEI (Administración Nacional de Laboratorios e Institutos de Salud, Instituto Nacional de Enfermedades Infecciosas) Buenos Aires, Argentina; Instituto Nacional de Laboratorios en Salud, Bolivia, Insitituto Adolfo Lutz, Sao Paulo, Brasil; CARA (Canadian Antimicrobial Resistance Alliance), Instituto de Salud Pública, Chile; Instituto Nacional de Salud, Colombia; Instituto Costarricense de Investigación y Enseñanza en Nutrición y Salud, Costa Rica; IPK (Insitituto de Medicina Tropical, Pedro Kouri), La Habana, Cuba; LNS-PDD (Laboratorio Nacional de Salud Pública), Dominican Republic; Instituto Nacional de Salud Pública e Investigación (INSPI), Ecuador; Laboratorio Central, Doctor Max Bloch, El Salvador; ECDC; Laboratorio Nacional de Salud, Guatemala; Laboratorio Nacional de Vigilancia, Doctor Alenjandro Lara, Tegucigalpa D.C Honduras; Instituto de Diagnóstico y Referencia Epidemiológicos, Mexico; CNDR MINSA (Centro Nacional de Diagnostico y renferencia, Ministerio de Salud), Managua, Nicaragua; Laboratorio de Salud Pública, Instituto Conmemorativo Gorgas LCRSP, Panama; Laboratorio Centralde Salud Pública, Paraguay; Instituto Nacional de Salud, Lima, Peru; Office of Antimicrobial Resistance, US Centers for Disease Control and Prevention, United States of America; Instituto Nacional de Higiene, Caracas, Venezuela. Finally, contributors, focal points and coordinators of the international networks ANSORP (Asian Network for Surveillance of Resistant Pathogens) and RusNet, and additional staff in the WHO Country Offices who provided support in the collection of data for this report are acknowledged.

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### **Financial support**

The Governments of Japan and Sweden

### **Declaration of Interest (DoI) from experts contributing to the WHO global report on AMR surveillance**

DoI forms were submitted by all external experts invited to contribute or to review the report. In the context of the scope of the work to be performed, none of the interest declared were regarded as of sufficient significance to impede the contribution of any expert to the work performed. A summary of the interests declared by the named individuals, the further information received upon follow-up and the outcome of the assessment of acceptability of the individual to contribute to the report development is available on request.



# Abbreviations

|          |                                                                             |
|----------|-----------------------------------------------------------------------------|
| ABR      | antibacterial resistance                                                    |
| AGISAR   | Advisory Group on Integrated Surveillance of Antimicrobial Resistance       |
| AMR      | antimicrobial resistance                                                    |
| ANSORP   | Asian Network for Surveillance of Resistant Pathogens                       |
| AST      | antibacterial susceptibility testing                                        |
| CA-MRSA  | community-acquired MRSA                                                     |
| CAESAR   | Central Asian and Eastern European Surveillance of Antimicrobial Resistance |
| CC       | Collaborating Centre                                                        |
| CDC      | US Centers for Disease Control and Prevention                               |
| CI       | confidence interval                                                         |
| CIPARS   | Canadian Integrated Program for Antimicrobial Resistance Surveillance       |
| DALY     | disability-adjusted life years                                              |
| DR-TB    | drug-resistant TB                                                           |
| DST      | drug susceptibility testing                                                 |
| ECDC     | European Centre for Disease Prevention and Control                          |
| EARS-Net | European Antimicrobial Resistance Surveillance Network                      |
| EFSA     | European Food Safety Authority                                              |
| ESBL     | extended spectrum beta-lactamase                                            |
| ESCMID   | European Society of Clinical Microbiology and Infectious Diseases           |
| EQA      | external quality assessment                                                 |
| EU       | European Union                                                              |
| FAO      | Food and Agriculture Organization of the United Nations                     |
| FWD-Net  | Foodborne and Waterborne Diseases and Zoonoses Network                      |
| GASP     | Gonococcal Antimicrobial Surveillance Programme                             |
| GFN      | Global Foodborne Infections Network                                         |
| GISP     | Gonococcal Isolate Surveillance Project                                     |
| GRASP    | Gonococcal Resistance to Antimicrobials Surveillance Programme              |
| ICU      | intensive care unit                                                         |
| IDSR     | Integrated Disease Surveillance and Response                                |
| LOS      | length of stay                                                              |
| MD       | mean difference                                                             |
| MDR-TB   | multidrug-resistant TB                                                      |
| MIC      | minimum inhibitory concentration                                            |
| MRSA     | methicillin-resistant <i>Staphylococcus aureus</i>                          |
| MSSA     | methicillin-susceptible <i>Staphylococcus aureus</i>                        |
| NICD     | National Institute for Communicable Diseases                                |
| NRL      | national reference laboratory                                               |



|         |                                                                                                                                                                                                         |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NS      | non-susceptible                                                                                                                                                                                         |
| NTS     | nontyphoid <i>Salmonella</i>                                                                                                                                                                            |
| OIE     | World Organisation for Animal Health                                                                                                                                                                    |
| PBP     | penicillin-binding protein                                                                                                                                                                              |
| PICO    | population, intervention, comparison, outcome                                                                                                                                                           |
| ReLAVRA | Latin American Antimicrobial Resistance Surveillance Network                                                                                                                                            |
| RR      | relative risk                                                                                                                                                                                           |
| SA      | <i>Staphylococcus aureus</i>                                                                                                                                                                            |
| SIREVA  | Sistema de Redes de Vigilancia de los Agentes Responsables de Neumonías y Meningitis Bacterianas (System of Networks for Surveillance of the Bacterial Agents Responsible for Pneumonia and Meningitis) |
| SRL     | supranational TB reference laboratory                                                                                                                                                                   |
| TB      | tuberculosis                                                                                                                                                                                            |
| WHA     | World Health Assembly                                                                                                                                                                                   |
| WHD     | World Health Day                                                                                                                                                                                        |
| WHO     | World Health Organization                                                                                                                                                                               |
| XDR     | extensively drug-resistant (TB)                                                                                                                                                                         |

## WHO regions and regional offices

|                       |                                              |
|-----------------------|----------------------------------------------|
| AFR/AFRO              | African Region/Regional Office               |
| AMR/AMRO <sup>a</sup> | Region of the Americas/Regional Office       |
| EMR/EMRO              | Eastern Mediterranean Region/Regional Office |
| EUR/EURO              | European Region/Regional Office              |
| PAHO                  | Pan American Health Organization             |
| SEAR/SEARO            | South-East Asia Region/Regional Office       |
| WPR/WPRO              | Western Pacific Region/ Regional Office      |

<sup>a</sup> The Pan American Sanitary Conference and the Directing Council of the Pan American Health Organization (PAHO) simultaneously serve as the WHO Regional Committee for the Americas, except when the Conference or the Council is considering matters relating to PAHO's Constitution, PAHO's juridical relations with WHO or the Organization of American States, or other questions relating to PAHO's role as an inter-American specialized organization.



# Introduction

For several decades antimicrobial resistance (AMR) has been a growing threat to the effective treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi. AMR results in reduced efficacy of antibacterial, antiparasitic, antiviral and antifungal drugs, making the treatment of patients difficult, costly, or even impossible. The impact on particularly vulnerable patients is most obvious, resulting in prolonged illness and increased mortality. The magnitude of the problem worldwide and the impact of AMR on human health, and on costs for the health-care sector and the wider societal impact, are still largely unknown.

Some estimates of the economic effects of AMR have been attempted, and the findings are disturbing. For example, the yearly cost to the US health system alone has been estimated at US \$21 to \$34 billion dollars, accompanied by more than 8 million additional days in hospital. Because AMR has effects far beyond the health sector, it was projected, nearly 10 years ago, to cause a fall in real gross domestic product (GDP) of 0.4% to 1.6%, which translates into many billions of today's dollars globally.

AMR is a complex global public health challenge, and no single or simple strategy will suffice to fully contain the emergence and spread of infectious organisms that become resistant to the available antimicrobial drugs. The development of AMR is a natural phenomenon in microorganisms, and is accelerated by the selective pressure exerted by use and misuse of antimicrobial agents in humans and animals. The current lack of new antimicrobials on the horizon to replace those that become ineffective brings added urgency to the need to protect the efficacy of existing drugs.

The development and implementation of effective strategies to curtail the emergence and spread of AMR, and to evaluate the effect of interventions to do so, depend on the collection of accurate representative information on the extent of the problem and its impact. WHO has for many years promoted the global monitoring of AMR and taken steps to raise awareness of the impending public health crisis it will cause. Among a range of WHO initiatives, in 2001 the *Global strategy for containment of antimicrobial resistance* (1) was published, and AMR was the focus of World Health Day in 2011 when a 6-point AMR policy package was issued (2). The World Health Assembly, through several resolutions over the years, has called for intensified implementation of the global strategy, stressing the need for strengthened surveillance of AMR and enhanced laboratory capacity to carry it out, and reduction in the inappropriate

use of antimicrobial drugs. The capacity to perform antimicrobial susceptibility testing, which can inform surveillance of AMR, also falls within the scope of the *International Health Regulations* (3), which stipulate the requirement for access by States Parties to capacity for investigation of any disease outbreak that may represent an international public health threat.

Many gaps remain in the efforts to contain AMR. Many diverse bacterial, viral, fungal and parasitic pathogens show resistance, and for some specific diseases (e.g. tuberculosis [TB], HIV, influenza and malaria) there are programmes in place that address resistance, and many of the most immediate and urgent concerns relate to antibiotic resistance in common bacteria. Antibacterial resistance (ABR)<sup>a</sup> involves bacteria that cause many common and life-threatening infections acquired in hospitals and in the community, for which treatment is becoming difficult, or in some cases impossible. Despite the importance of these infections, there are major gaps in information concerning the extent, spread, evolution and impact of ABR. Urgency is added in particular by the lack of new therapeutic options in the development pipeline to replace those that lose their efficacy as bacteria become resistant to them. Thus, the main focus of this report is on ABR, for which knowledge, support and concerted action are inadequate.

Although ABR surveillance has been undertaken for many years in a number of high-income countries, there are still large gaps in knowledge about the status of ABR surveillance capacities worldwide, particularly in resource-limited settings. This report attempts to map ABR surveillance status in Member States, and specifically the availability of data from national official sources.

This is the first attempt by WHO to assemble the accessible information on national ABR surveillance and on ABR data for a set of common pathogenic bacteria, in order to present an analysis of the global situation as it appeared in 2013, together with an examination of the evidence base concerning the health and economic impact of ABR. The information gathered highlights the strengths and weaknesses in both the collection of data and the quality of data collected in Member States, and demonstrates the need for further effort and investment.

In addition to gathering information on ABR surveillance and ABR occurrence, the report also summarizes the situation in major disease-specific control programmes (i.e. HIV, influenza, malaria and TB) and in related fields (i.e. foodborne and fungal infections).

<sup>a</sup> Although *Mycobacterium tuberculosis*, the main cause of tuberculosis, is also a bacterium, it has specific features and is described separately in Section 4.1.

The report has the following structure and specific focus:

- **Section 1** gives an overview of ABR surveillance in the different WHO regions.
- **Section 2** examines the availability and status of resistance data in Member States for a set of common bacteria of importance to global public health.
- **Section 3** examines the available evidence concerning the health and economic burden due to ABR in a subset of the selected bacteria, based on a systematic review of the scientific literature.
- **Section 4** provides summaries of surveillance and the status of AMR in TB, malaria, HIV and influenza.
- **Section 5** summarizes key issues in surveillance and AMR in foodborne pathogens and fungal infections.
- **Section 6** discusses the main findings from the data and information assembled for the report (noting the main gaps in knowledge), and considers directions for future work in this field.
- **Annexes 1–3** provide:
  - a description of the methods used to obtain data;
  - all of the collected data and sources of information for each of the selected bacteria, country by country in each WHO region; and
  - a detailed technical report on the systematic review of the evidence on health and economic burden due to ABR.
- **Appendices 1–3** provide:
  - the questionnaires used to obtain data on resistance;
  - the available WHO tools to facilitate surveillance of ABR;
  - the list of *International statistical classification of diseases and related health problems* (ICD) codes related to ABR; and
  - a description of some international ABR surveillance networks.

For this first report, for which no common agreed methodology for surveillance of ABR existed, it was not feasible to compare the accuracy of the submitted data. Nonetheless, despite gaps and other shortcomings, the data do give at least an indication of the current worldwide status of ABR at country level. The report also establishes a baseline against which progress in strengthening global surveillance capacities and standards can be measured. It is important to note that the national data on ABR have been compiled for the purpose of a situation analysis of global surveillance, rather than as a basis for decisions on clinical care of patients, for which standard treatment guidelines should be followed.

The report is intended to provide information primarily for public health policy-makers and managers, and for the wider medical and public health community (including pharmaceutical companies), as a support for informing strategic actions and programme planning. It will also be of interest to the other sectors that are directly involved, including veterinary drug and animal husbandry, agriculture and aquaculture.

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# SECTION 01

# Resistance to antibacterial drugs

## 1.1 Background

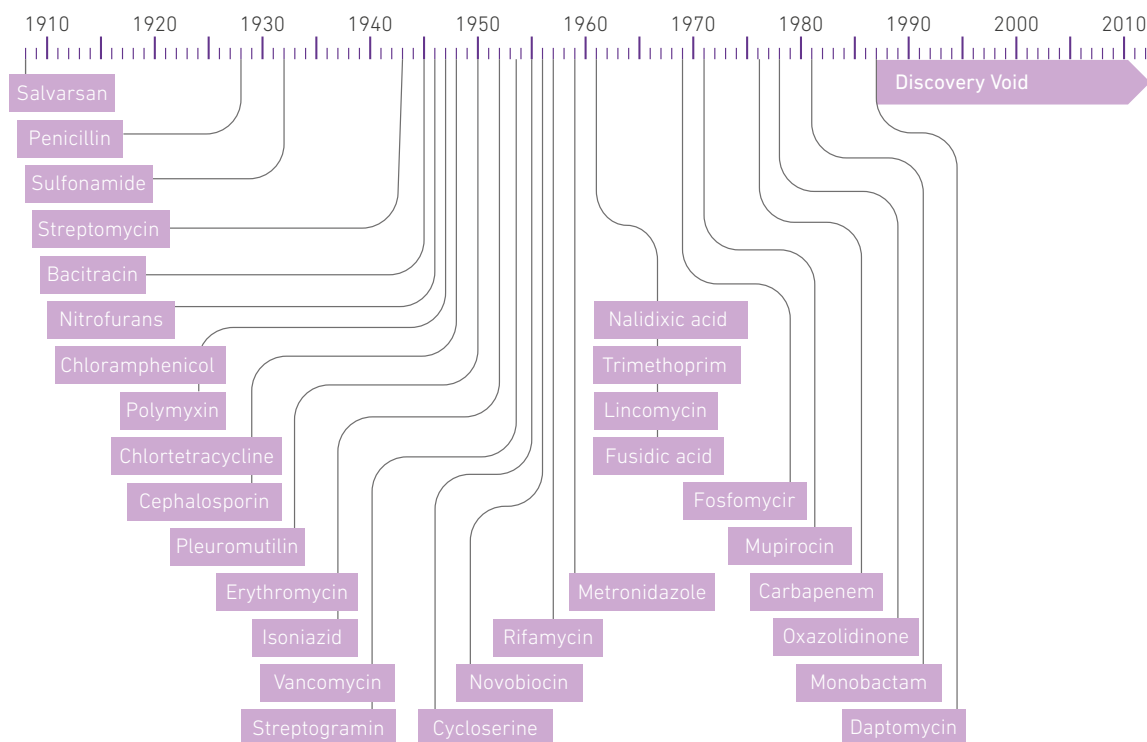
For more than 60 years, antibacterial drugs<sup>a</sup> have been regarded as the panacea to cure infections, whether or not their use is appropriate, and whether the infection was acquired in the community or in the hospital setting. Already in his Nobel Prize speech in 1945, Alexander Fleming, who discovered penicillin, warned that bacteria could become resistant to these remarkable drugs. Indeed, the development of each new antibacterial drug has been followed by the detection of resistance to it. The development of resistance is a normal evolutionary process for microorganisms, but it is accelerated by the selective pressure exerted by widespread use of antibacterial drugs. Resistant strains are able to propagate and spread where there is non-compliance with infection prevention and control measures.

Use of antibacterial drugs has become widespread over several decades (although equitable access to antibacterial drugs is far from being available worldwide), and these drugs have been extensively misused in both humans and food-producing animals in ways that favour the selection and spread of resistant bacteria. Consequently, antibacterial drugs have become less effective or even ineffective, resulting in an accelerating global health security emergency that is rapidly outpacing available treatment options.

Until the 1970s, many new antibacterial drugs were developed to which most common pathogens were initially fully susceptible, but the last completely new classes of antibacterial drugs were discovered during the 1980s (Figure 1). It is essential to preserve the efficacy of existing drugs through measures to minimize the development and spread of resistance to them, while efforts to develop new treatment options proceed.

**Figure 1** Dates of discovery of distinct classes of antibacterial drugs

Illustration of the “discovery void.” Dates indicated are those of reported initial discovery or patent.



Adapted from Silver 2011 (1) with permission of the American Society of Microbiology Journals Department.

<sup>a</sup> Antibacterial drugs act against bacteria and include antibiotics (natural substances produced by microorganisms), and antibacterial medicines, produced by chemical synthesis.

Greater emphasis should be placed on prevention, including strengthening hygiene and infection prevention and control measures, improving sanitation and access to clean water, and exploring a more widespread use of vaccines. Although preventive vaccines have become available for several bacterial infections, their application is still limited.

The pipeline for the development of new antibacterial drugs is now virtually empty, particularly for the treatment of Gram-negative enteric bacteria,<sup>a</sup> and research on treatments to replace antibacterial drugs is still in the early stages. Situations are increasingly arising where bacteria that are resistant to most, or even all, available antibacterial drugs are causing serious infections that were readily treatable until recently. This means that progress in modern medicine, which relies on the availability of effective antibacterial drugs, is now at risk, as exemplified in the following situations:

- Common community-acquired infections such as pneumonia, which used to be readily treatable after the introduction of penicillin, may not respond to available or recommended drugs in many settings, putting the lives of patients at risk.
- Cystitis, one of the most common of all bacterial infections in women, which readily responded to oral treatment in the past, may need to be treated by injected drugs, imposing additional costs for patients and health systems, or become untreatable.
- Common infections in neonatal and intensive care are increasingly becoming extremely difficult, and sometimes impossible, to treat.
- Patients receiving cancer treatment, organ transplants and other advanced therapies are particularly vulnerable to infection. When treatment of an infection fails in such patients, the infection is likely to become life-threatening and may be fatal.
- Antibacterial drugs used to prevent postoperative surgical site infections have become less effective or ineffective.

Major gaps in data on the extent of ABR, and on the types and number of infections caused by bacteria that have become resistant to antibacterial drugs, make it impossible to estimate precisely the global prevalence and impact of the problem. Nevertheless, it is abundantly clear that together, the burden of morbidity and mortality resulting from ABR in many infections and settings has serious consequences for individuals and society in terms of clinical outcomes and added costs.

The collection of reliable information about the ABR situation through well-conducted surveillance is essential to inform strategies and prioritize

interventions to tackle the problem. ABR surveillance should generate data to support action at all levels: local, national, regional and global. Countries with appropriate surveillance systems have the ability to:

- obtain national information on the magnitude and trends in resistance;
- detect emerging problems;
- follow the effect of interventions and countermeasures;
- inform treatment guidelines, decision-making and a research agenda;
- collect information on the public health burden of ABR; and
- participate in international networks for data sharing and monitoring of trends to inform global strategies.

### 1.1.1 Limitations

This report describes the current situation of ABR surveillance and ABR rates for selected types of bacterial resistance worldwide. The ABR rates presented in this report include a compilation of the available data as reported by countries and surveillance programmes, and in scientific journal articles. The priority was to obtain data from national official sources, such as reports or other compilations at the national level at ministries of health, national reference laboratories, public health institutes or other sources identified by WHO. When data from national official sources were not available or were available in sample sizes that were too small (i.e. fewer than 30 isolates tested), other sources (i.e. non-official networks and scientific journal articles) were sought. The search of scientific journal articles as a complementary source was not intended as a full review of all available publications. Despite the attempt at standardized data collection (methodology described in Annex 1), the compilation of data from various sources proved challenging in this first report.

Given the lack of agreed global standards for ABR surveillance, the reported proportions of resistance should be interpreted with caution. The discrepancies in performance and interpretation of laboratory findings can be such that bacteria considered resistant in one laboratory could be classified as susceptible if tested in another laboratory. The resistance proportions should therefore be regarded as indicators, rather than measures, of the proportion of ABR as it is perceived where the data originate, according to prevailing methodology and the population sampled.

Data from national sources and publications are presented in this report as they were received or obtained from the data source. It was beyond the scope of the report to assess the validity and representativeness of the data. Data from some Member States may not have been obtained for this

<sup>a</sup> For example, intestinal bacteria such as *Escherichia coli* and *Klebsiella*, and environmental opportunistic bacteria such as *Pseudomonas* and *Acinetobacter*



report, despite being available at subnational or local levels.

Caution is necessary in interpreting the available data. Limited and skewed patient samples, particularly from hospital patients, are not likely to be representative of the general situation, and could lead to overestimation of the overall resistance problem among all patients in the population. This situation may influence clinicians to make greater use of broad-spectrum antibacterial drugs than is warranted, which in turn will accelerate the emergence and spread of resistance, and add to treatment costs. Therefore, the data presented in this report should not be used to inform local treatment protocols.

The proportions of resistant bacteria are determined based on results from antibacterial susceptibility testing (AST). The methodologies addressing molecular aspects of ABR are not available in most settings. Thus, despite its importance in understanding how bacterial populations and genetic elements spread, molecular epidemiology data has not been included in this report.

The data obtained for this report reveal limitations with regard to heterogeneity of methodology used by the various sources and to representativeness and quality assurance, but nevertheless provide useful insight into the current global status of ABR and surveillance gaps, creating a basis to inform further developments in this field.

## 1.2 Regional surveillance of antibacterial resistance

### 1.2.1 WHO African Region

Information concerning the true extent of the problem of AMR in the African Region is limited because surveillance of drug resistance is carried out in only a few countries. There is a scarcity of accurate and reliable data on AMR in general, and on ABR in particular, for many common and serious infectious conditions that are important for public health in the region, such as meningitis, pneumonia and bloodstream infections.

The WHO Member States endorsed the Integrated Disease Surveillance and Response (IDSR) strategy in 1998. Effective implementation of IDSR is a way to strengthen networks of public health laboratories, and thus contribute to effective monitoring of AMR. However, a recent external quality assessment of public health laboratories in Africa revealed weakness in antimicrobial susceptibility testing in many countries (2).

Faced with multiple dimensions of the ABR threat to public health, some countries have established national and regional surveillance collaborations. However, there is no formal framework for collaboration among surveillance programmes across the region. The lack of a regional framework for collaborative surveillance of ABR, with no collection and sharing of information between networks of laboratories, hampers efforts to track and contain the emergence of resistant organisms, and to systematically evaluate trends and resistance-containment activities in the region.

Despite limited laboratory capacity to monitor ABR, available data indicate that the African Region shares the worldwide trend of increasing drug resistance. Significant resistance has been reported for several bacteria that are likely to be transmissible not only in hospitals but also in the community.

To contribute to the improvement of surveillance of ABR at country level, the WHO Regional Office for Africa (AFRO) recently published a guide to facilitate the establishment of laboratory-based surveillance for priority bacterial diseases in the region (3). Collection, sharing and regular dissemination of data can be used by public health policy-makers to regularly update the national AMR policy as necessary.

### 1.2.2 WHO Region of the Americas

ReLAVRA, the Latin American Antimicrobial Resistance Surveillance Network, was created in 1996 and is led by the WHO Regional Office for the Americas/Pan American Health Organization (AMRO/PAHO), in order to collect aggregated data provided by national reference laboratories (NRLs). At that time, the network involved eight NRLs in the region. The countries agreed to maintain and support the NRLs, which compile information on the identification of the bacterial species isolated and their susceptibility to antibacterial drugs. Also, the NRLs verify the application of the principles of quality assurance in laboratories participating in the national network, and are responsible for performance evaluation. An external quality control programme for the network is carried out by two centres, in Argentina and Canada. Currently, NRLs from 19 countries in Latin America plus Canada and the USA are part of the network. English-speaking Caribbean countries are invited to share their data but do not yet participate directly in the network.

ReLAVRA has increased its ability to detect, monitor and manage data on ABR, based on the growing number of countries participating in the network. As an example, 72 000 bacterial isolates were analysed in 2000, and more than 150 000 in 2010. This increase in the number of isolates studied

is due in large part to isolates of hospital origin, reflecting the progressive incorporation of hospitals into the network. More information on the origin of the samples, and their distribution, would enable better assessment of their representativeness.

Coordination by a single agency, AMRO/PAHO, which standardizes the systems for data collection and the use of external quality assurance processes for the network members, has been an important strength of the network. Surveillance protocols are aligned with the WHO recommendations for diarrhoeal disease and respiratory tract infections. The antibacterials selected for the susceptibility tests include those recommended by WHO.

ReLAVRA has not only strengthened national laboratory networks, it has also generated data for decision-making (4); for example, for informing guidelines on the empirical use of antibacterial drugs.

The Sistema de Redes de Vigilancia de los Agentes Responsables de Neumonías y Meningitis Bacterianas – SIREVA II (5) – is a network in Latin America that was initiated by AMRO/PAHO in 1993 to provide a regional monitoring programme for important bacteria causing pneumonia and meningitis. The network is built on sentinel hospitals and laboratories that provide:

- data on serotype distribution and antibacterial susceptibility for *Streptococcus pneumoniae*, *Haemophilus influenzae* and *Neisseria meningitidis*; and
- epidemiological information for estimating the burden of these diseases and the development of increasingly efficient vaccines.

### 1.2.3 WHO Eastern Mediterranean Region

The collection of resistance information from disease-specific programmes (e.g. TB, HIV and malaria) is relatively advanced in the Eastern Mediterranean Region, but estimates of the magnitude of the wider problem associated with AMR, and the health and socioeconomic burden resulting from it, are hampered by the limited availability of reliable data. Nonetheless, reports and studies from some countries in the region show the geographically extensive emergence of ABR (see Section 2).

Preliminary results obtained through limited country situation analyses in the region have revealed several challenges that need to be tackled as a matter of urgency. Lack of robust functioning national ABR surveillance systems and lack of collaboration with the animal health sector means that insufficient evidence is available for policy-makers to set appropriate policies, strategies and plans to combat ABR. Other challenges include the absence of legislation or the lack of enforcement of laws (where they exist). In countries

currently experiencing complex humanitarian emergencies in the region, there is disruption of basic health services. This also impedes the response to AMR (including ABR) in the affected countries.

Mindful of the public health threats posed by the current trends in AMR, in 2002 and in 2013, the Eastern Mediterranean Regional Committee adopted resolutions addressing AMR (6, 7). However, due to the complexity of the efforts required to tackle AMR and the need to focus on other pressing priorities in the region, the response to the threat of AMR has remained fragmented.

### 1.2.4 WHO European Region

Currently, most countries of the European Union (EU) have well-established national and international surveillance systems for AMR, whereas countries in other parts of the European Region require strengthening or establishment of such systems. The WHO Regional Office for Europe (EURO) has been supporting these Member States in this endeavour.

The European Antimicrobial Resistance Surveillance Network – EARS-Net (8) – is an international surveillance system that includes all 28 EU countries plus Iceland and Norway. EARS-Net is currently coordinated by the European Centre for Disease Prevention and Control (ECDC). The network includes surveillance of antibacterial susceptibility of eight indicator pathogens causing bloodstream infections and meningitis; it also monitors variations in AMR over time and place. The standardized data collected in EARS-Net have formed the basis for drawing maps of the situation of resistance in the indicator bacteria across Europe in the network's annual report. These maps have been much appreciated and stimulated action to contain AMR in participating countries (9).

The Central Asian and Eastern European Surveillance of Antimicrobial Resistance – CAESAR (10) – is a new joint initiative of EURO, the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and The Dutch National Institute for Public Health and the Environment (RIVM). The aim is to support all countries of the region that are not part of EARS-Net to develop a network of national surveillance systems for ABR. This initiative strives to enable countries to strengthen AMR epidemiology, as well as laboratory capacity and quality. To facilitate comparison of data throughout the entire European Region, the methodology used in CAESAR adopts the EARS-Net methodology, with the work carried out in close collaboration with ECDC.

The Foodborne and Waterborne Diseases and Zoonoses Network – FWD-Net (11) – is a European network coordinated by the ECDC. AMR data are collected for foodborne bacteria, such as *Salmonella* and *Shigella*, as part of the network's surveillance activities. The data

are published annually in a joint report by the ECDC and the European Food Safety Authority (EFSA) on AMR in zoonotic and indicator bacteria from humans, animals and food products in the EU (12).

### 1.2.5 WHO South-East Asia Region

Systematic efforts to collect data on the epidemiology of antimicrobial resistance have not yet been undertaken in the South-East Asia Region. However, information and data available for selected diseases and organisms reveal that AMR is a burgeoning and often neglected problem.

In 2011, the health ministers of the region's Member States articulated their commitment to combat AMR through the Jaipur Declaration on AMR (13). Since then, there has been growing awareness throughout the region that containment of AMR depends on coordinated interventions, including appropriate surveillance of drug resistance. All 11 Member States (6 of which already have national systems in place) have agreed to contribute information for a regional database and to participate in a regional consultative process. A more detailed description of the present situation in each country is available in a report from a recent regional workshop (14).

### 1.2.6 WHO Western Pacific Region

In the 1980s, 14 Member States in the Western Pacific Region agreed to share AMR findings for more than 20 key hospital and community pathogens on an annual basis, and annual reports were compiled and distributed to network participants. Unfortunately, the collaboration was interrupted because of a series

of other emergencies in the early 2000s. A summary of the experience (15) concluded that “the data reviewed for the Report... reveal serious problems and worsening trends in antimicrobial resistance in various nations of the Region”. Many of the contributing Member States actively used the data and, despite the loss of coordination activities, have continued to develop ABR surveillance at a national level. Recently, the WHO Regional Office for the Western Pacific (WPRO) has taken steps to revive surveillance of AMR in the region.

Most high-income countries in the region have long-established systems for routine surveillance of ABR (including quality assurance), at least in health-care settings, that provide some form of national oversight. There are also links to national and local policies, especially the development of standard treatment guidelines. However, even in some of these high-income countries there are gaps in geographic coverage and lack of surveillance in community settings. Among upper middle-income countries, some have younger AMR surveillance programmes of similar quality to those in most high-income countries, with similar (but larger) gaps. In all these countries there is a high level of technical expertise, which provides an excellent opportunity for further development and collaboration. In the lower middle-income countries there is greater variation in the level and quality of surveillance. The quality of AST may be uncertain in some countries, whereas others have operated fairly extensive and high-quality sentinel AMR surveillance programmes for decades. Some Pacific Island countries face particular challenges given the low sample numbers, lack of human resources and geographic remoteness.

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# SECTION 02

# Resistance to antibacterial drugs in selected bacteria of international concern

For this first WHO report on the global status of ABR and surveillance, information was compiled on resistance to antibacterial drugs commonly used to treat infections caused by nine bacteria of international concern.

- *Escherichia coli*: resistance to third-generation cephalosporins, including resistance conferred by extended spectrum beta-lactamases (ESBLs), and to fluoroquinolones;
- *Klebsiella pneumoniae*: resistance to third-generation cephalosporins, including resistance conferred by ESBLs, and to carbapenems;
- *Staphylococcus aureus*: resistance to beta-lactam antibacterial drugs (methicillin, methicillin-resistant *S. aureus* [MRSA]);
- *Streptococcus pneumoniae*: resistance or non-susceptibility to penicillin (or both);
- Nontyphoidal *Salmonella* (NTS): resistance to fluoroquinolones;
- *Shigella* species: resistance to fluoroquinolones;
- *Neisseria gonorrhoeae*: decreased susceptibility to third-generation cephalosporins.

These types of ABR have a significant public health impact worldwide because they are common etiologies for hospital or community-acquired infections, or both.

A detailed description of the methodology for the data collection is available in Annex 1. In summary, data were collected from the following sources:

- national official sources, such as reports or other compilations at the national level at ministries of health, national reference laboratories, public health institutes or other sources identified by WHO;
- national and international networks for ABR surveillance (if data from national official sources were not available or available in too low sample size; i.e. < 30 isolates tested); and
- scientific journal articles published from 2008 (when data from above sources were not available or available in too low sample size; i.e. < 30 isolates tested).

This section summarizes the main results of the data collection. The details of data obtained are provided in Annex 2.

Interpretation of the data summarized in this report should take account of its precision and representativeness, including the following considerations:

- There is no general agreement on how many bacterial isolates should be tested in order to present a reasonably accurate figure of the resistance proportion. However, the minimum number of tested isolates considered sufficient to present reported proportions of resistance in this section was arbitrarily set at 30.
- The origin of samples is usually skewed towards severely ill hospitalized patients, whose condition did not respond to first-line treatment. This imbalance will generally result in higher proportions of resistance in the collected samples than would be found for a broader, more representative sample of patients in the population.
- Some of the published studies, particularly those on *S. pneumoniae* and MRSA, are based on sampling of healthy carriers without symptoms, which further adds to difficulties in interpretation of public health impact and comparison of resistance proportions.
- It is known that differences exist in the methodology and quality in performance of AST in different countries and regions, which will limit the comparability of results across the various data sources.



## 2.1 Availability of national resistance data

A response including data, or information that no national data were available, was returned from 129 of the 194 WHO Member States (66%). Of these, 114 provided some data for at least one bacteria–antibacterial drug-resistance combination, as shown in Table 1 and Figure 2.

**Table 1** Information from returned questionnaires, or other sources, on availability of national data on resistance for the requested nine bacteria–antibacterial drug resistance combinations

|                                                | WHO region  |                       |             |                  |                |                | Total         |
|------------------------------------------------|-------------|-----------------------|-------------|------------------|----------------|----------------|---------------|
|                                                | AFR         | AMR/PAHO <sup>a</sup> | EMR         | EUR <sup>a</sup> | SEAR           | WPR            |               |
| No. of Member States returning information (%) | 27/47 (57%) | 21/35 (60%)           | 11/21 (52%) | 42/53 (79%)      | 9/11 (82%)     | 19/27 (70%)    | 129/194 (66%) |
| Returned data set(s)/no. of Member States (%)  | 23/47 (49%) | 21/35 (60%)           | 7/21 (32%)  | 38/53 (74%)      | 6/11 (55%)     | 19/27 (70%)    | 114/194 (59%) |
| Responded “No national data available”         | 4           | –                     | 4           | 4                | 3 <sup>b</sup> | 0 <sup>c</sup> | 15            |
| No information obtained for this report        | 20          | 14                    | 10          | 11               | 2              | 8              | 65            |

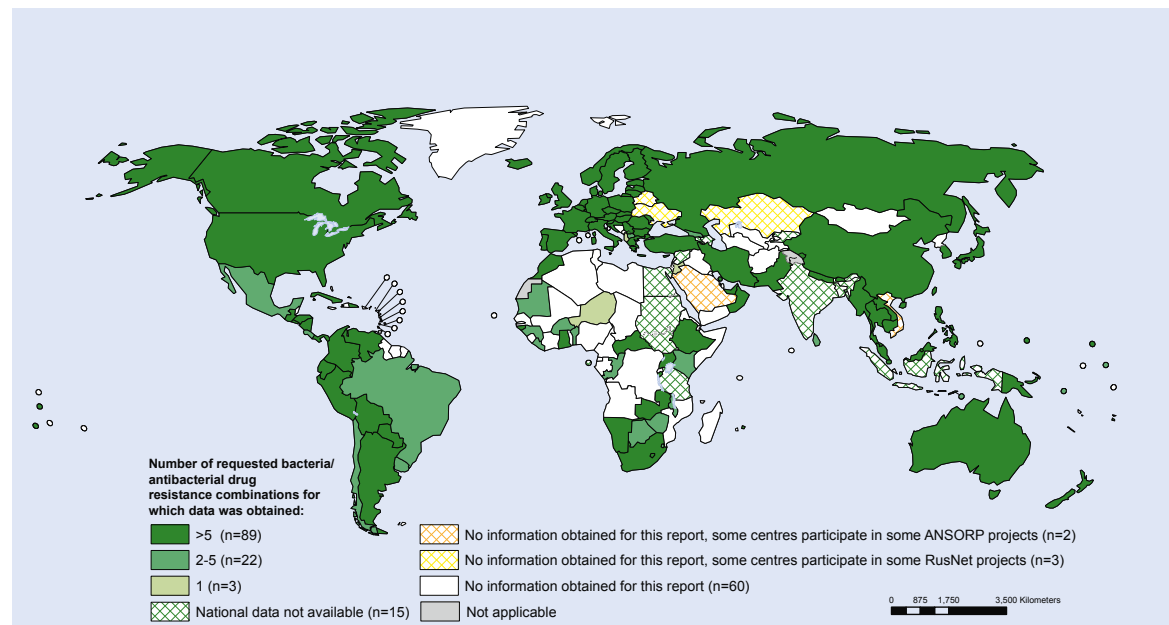
AFR, African Region; AMR/PAHO, Region of the Americas/Pan American Health Organization; EMR, Eastern Mediterranean Region; EUR, European Region; SEAR, South-East Asia Region; WPR, Western Pacific Region.

a. To avoid duplicate data collection, ECDC, European Centre for Disease Prevention and Control and AMRO forwarded data already collected in their existing surveillance networks.

b. One country responded there was no national data compilation but still returned data.

c. Two countries responded there was no national data compilation but still returned data.

**Figure 2** Availability of data on resistance for selected bacteria–antibacterial drug combinations, 2013



Number of reported bacteria is based on the information obtained based on request to national official sources on antibacterial susceptibility testing of at least one of the requested combinations, regardless of denominator data.

Data from United Arab Emirates originate from Abu Dhabi only.



Table 2 shows that the overall proportion of data sets obtained from national official sources for each bacteria–antibacterial drug combination based on at least 30 tested bacterial isolates was 79%.

This proportion ranged from 56% to 92% across the regions, and between 56% and 90% for the different bacteria–antibacterial drug resistance combinations.

**Table 2 Overview of data sets obtained on request to national official sources that included information on at least 1 of the 9 selected bacteria–antibacterial drug resistance combinations based on testing of at least 30 isolates**

|                                                                         | For each bacteria–antibacterial drug–resistance combination <sup>a</sup> :<br>no. of returned data sets <sup>b</sup> based on at least 30 tested isolates/total no. of data sets for each requested combination <sup>c</sup> |               |             |               |             |               |                                                                  |
|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------|---------------|-------------|---------------|------------------------------------------------------------------|
|                                                                         | AFR                                                                                                                                                                                                                          | AMR/PAHO      | EMR         | EUR           | SEAR        | WPR           | Total no. of reports with data sets based on ≥30 tested isolates |
| <i>E. coli</i> / 3 <sup>rd</sup> generation cephalosporins <sup>d</sup> | 13/19                                                                                                                                                                                                                        | 14/15         | 5/7         | 35/36         | 5/5         | 14/19         | 86/101 (85%)                                                     |
| <i>E. coli</i> / fluoroquinolones <sup>e</sup>                          | 14/19                                                                                                                                                                                                                        | 16/16         | 5/7         | 35/35         | 5/5         | 17/20         | 92/102 (90%)                                                     |
| <i>K. pneumoniae</i> / 3 <sup>rd</sup> generation cephalosporins        | 13/16                                                                                                                                                                                                                        | 17/17         | 5/7         | 33/37         | 4/5         | 15/17         | 87/99 (88%)                                                      |
| <i>K. pneumoniae</i> / carbapenems <sup>f</sup>                         | 4/7                                                                                                                                                                                                                          | 17/17         | 5/7         | 31/35         | 4/5         | 10/12         | 71/83 (86%)                                                      |
| Methicillin-resistant <i>S. aureus</i> (MRSA)                           | 9/15                                                                                                                                                                                                                         | 15/17         | 5/7         | 36/37         | 3/4         | 17/19         | 85/99 (86%)                                                      |
| <i>S. pneumoniae</i> non-susceptible or resistant to penicillin         | 5/14                                                                                                                                                                                                                         | 15/21         | 3/5         | 31/35         | 2/5         | 11/18         | 67/97 (69%)                                                      |
| Nontyphoidal <i>Salmonella</i> / fluoroquinolones                       | 9/19                                                                                                                                                                                                                         | 13/20         | 4/5         | 29/30         | 2/4         | 11/13         | 68/91 (75%)                                                      |
| <i>Shigella</i> species/ fluoroquinolones                               | 4/12                                                                                                                                                                                                                         | 14/19         | 2/3         | 10/12         | 0/2         | 5/9           | 35/57 (61%)                                                      |
| <i>N. gonorrhoeae</i> / 3 <sup>rd</sup> generation cephalosporins       | 2/10                                                                                                                                                                                                                         | 4/12          | 2/3         | 17/22         | 5/7         | 12/21         | 42/75 (56%)                                                      |
| Total no. of reports with data sets based on ≥30 tested isolates        | 73/131 (56%)                                                                                                                                                                                                                 | 125/154 (81%) | 36/51 (71%) | 257/279 (92%) | 30/42 (71%) | 112/147 (76%) | Total 636/805 (79%)                                              |

AFR, African Region; AMR/PAHO, Region of the Americas/Pan American Health Organization; ECDC, European Centre for Disease Prevention and Control; EMR, Eastern Mediterranean Region; EUR, European Region; SEAR, South-East Asia Region; WPR, Western Pacific Region.

a. Not all countries returned information for all combinations.

b. To avoid duplicate data collection, ECDC and AMRO/PAHO forwarded data already collected in their existing surveillance networks.

c. From countries providing several data sets, one per country and data with highest denominator is included in this table.

d. 3<sup>rd</sup> generation cephalosporins mentioned in obtained national data are ciprofloxacin; gatifloxacin; levofloxacin; moxifloxacin; norfloxacin; ofloxacin; pefloxacin; rifloxacin and sparflaxacin.

e. Fluoroquinolones mentioned in obtained national data are ciprofloxacin, norfloxacin or ofloxacin.

f. Carbapenems mentioned in obtained national data are imipenem, meropenem, doripenem or ertapenem.

Data based on small sample sizes increase the uncertainty of the results. The gaps in data may be indicative of the difficulties in gathering information for this first global report, as well as insufficient capacity in the health systems. Limited health-system capacity may result in insufficiencies in sampling of patients,

laboratory capacity for analysis, compilation of results at the laboratory level or collection of aggregated data from laboratories at the national level, as well as other priorities or difficulties. These factors will vary between countries.

### 2.1.1 Key messages

- Of the 194 Member States, 129 (66%) returned information for the survey forming the basis for this report on national surveillance data. Of these, 114 Member States returned some data on at least one of the requested bacteria–antibacterial drug resistance combinations.
- There is wide variability in the availability of information on ABR at national level, and considerable gaps remain in the capacity of a substantial number of countries to produce national data based on testing of sufficient isolates to obtain reasonably reliable figures for the sampled population.
- The largest gaps in the obtained data were seen in Africa, the Middle East and EUR Member States outside the EU.

## 2.2 Resistance data on specific pathogens

### 2.2.1 *Escherichia coli* – resistance to third-generation cephalosporins and to fluoroquinolones

*E. coli* is part of the normal flora in the intestine in humans and animals. Nevertheless it is:

- the most frequent cause of community and hospital-acquired urinary tract infections (including infections of the kidney);
- the most frequent cause of bloodstream infection at all ages;
- associated with intra-abdominal infections such as peritonitis, and with skin and soft tissue infections due to multiple microorganisms;
- a cause of meningitis in neonates; and
- one of the leading causative agents of foodborne infections worldwide.

Infections with *E. coli* usually originate from the person affected (auto-infection), but strains with a particular resistance or disease-causing properties can also be transmitted from animals, through the food chain or between individuals.

#### Evolution of antibacterial resistance in *Escherichia coli*

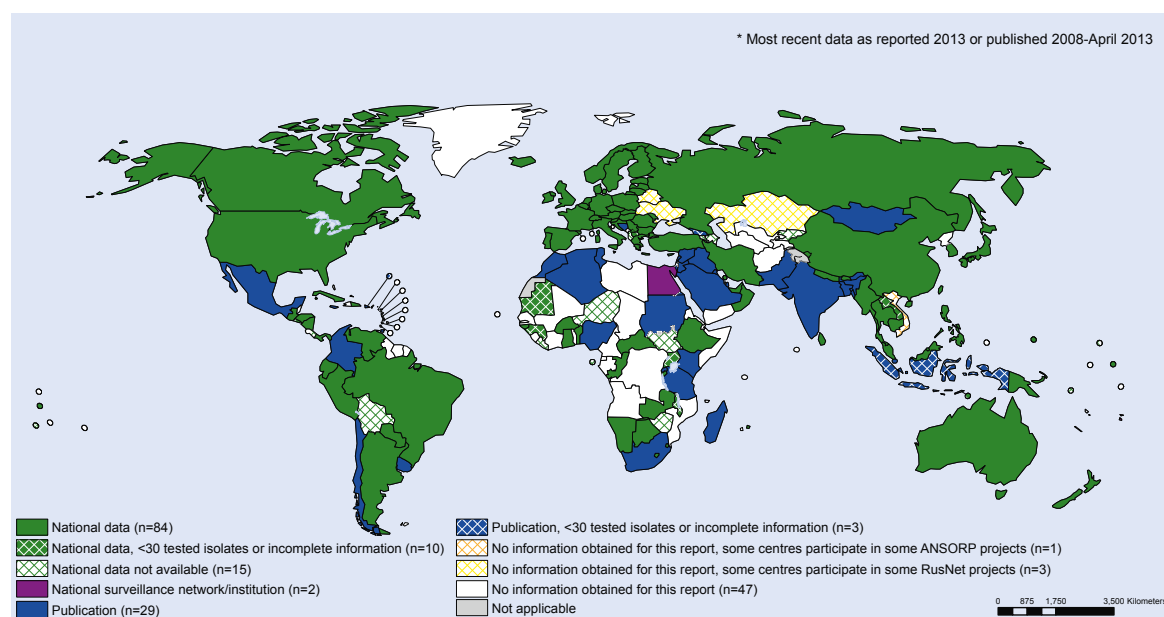
- Resistance in *E. coli* readily develops either through mutations, which is often the case for fluoroquinolone

resistance, or by acquisition of mobile genetic elements, which has been the case for broad-spectrum penicillins (e.g. ampicillin or amoxicillin) and resistance to third-generation cephalosporins.

- Resistance to third-generation cephalosporins is mainly conferred by enzymes known as extended spectrum beta-lactamases (ESBLs); these enzymes destroy many beta-lactam antibacterial drugs. ESBLs are transmissible between bacteria and even between bacterial species. Because *E. coli* strains that have ESBL are generally also resistant to several other antibacterial drugs, carbapenems usually remain the only available treatment option for severe infections. A recently emerging threat is carbapenem resistance in *E. coli* mediated by metallo-beta-lactamases, which confers resistance to virtually all available beta-lactam antibacterial drugs.
- This report focuses on available data on proportions of *E. coli* resistant to third-generation cephalosporins, which are widely used for intravenous treatment of severe infections in hospitals, and to fluoroquinolones, which are among the most widely used oral antibacterial drugs in the community.

#### Resistance to third-generation cephalosporins in *Escherichia coli*

Figure 3 illustrates sources for obtained resistance data in countries according to the methods described in Annex 1.

**Figure 3** Sources of data on *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>

National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.1–A2.6, Annex 2).

a. ceftazidim; cefotaxim; ceftriaxone

Data obtained from Member States are summarized by WHO region in Table 3. Details at country level are provided in Tables A2.1–A2.6, Annex 2.

**Table 3** *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup> (summary of reported or published proportions of resistance, by WHO region)

| Data sources based on at least 30 tested isolates <sup>b</sup>                                                                                                                           | Overall reported range of resistant proportion (%) | Reported range of resistant proportion (%) in invasive isolates <sup>c</sup> (no. of reports) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| <b>African Region</b><br>– National data (n=13 countries)<br>– Publications (n=17) from 7 additional countries                                                                           | 2–70<br>0–87                                       | 28–36 (n=4)<br>0–17 (n=5)                                                                     |
| <b>Region of the Americas</b><br>– National data or report to ReLAVRA (n=14 countries)<br>– Publications (n=10) from 5 additional countries                                              | 0–48<br>0–68                                       |                                                                                               |
| <b>Eastern Mediterranean Region</b><br>– National data (n=4 countries)<br>– Surveillance network in 1 country <sup>d</sup><br>– Publications (n=44) from 11 additional countries         | 22–63<br>39 (caz)–50 (cro)<br>2–94                 | 41 (n=1)<br>11–33 (n=6)                                                                       |
| <b>European Region</b><br>– National data or report to EARS-Net (n=35 countries)<br>– Publications (n=5) from 2 additional countries                                                     | 3–82<br>0–8                                        | 3–43 (n=32)<br>0–8 (n=2)                                                                      |
| <b>South-East Asia Region</b><br>– National data (n=5 countries)<br>– Publications (n=26) from 2 additional countries                                                                    | 16–68<br>19–95                                     | 20–61 (n=2)                                                                                   |
| <b>Western Pacific Region</b><br>– National data (n=13 countries)<br>– Institute surveillance (data from 3 hospitals in one country)<br>– Publications (n=4) from 2 additional countries | 0–77<br>4–14<br>8–71                               |                                                                                               |

EARS-Net, European Antimicrobial Resistance Surveillance Network; ReLAVRA, Latin American Antimicrobial Resistance Surveillance Network. (For details see Annex 2, Tables A2.1–A2.6).

a. Based on antibacterial susceptibility testing with caz, ceftazidim; cefotaxim or cro, ceftriaxone

b. Reported proportions may vary between compound used for testing and some countries report data for several compounds, or data from more than one surveillance system.

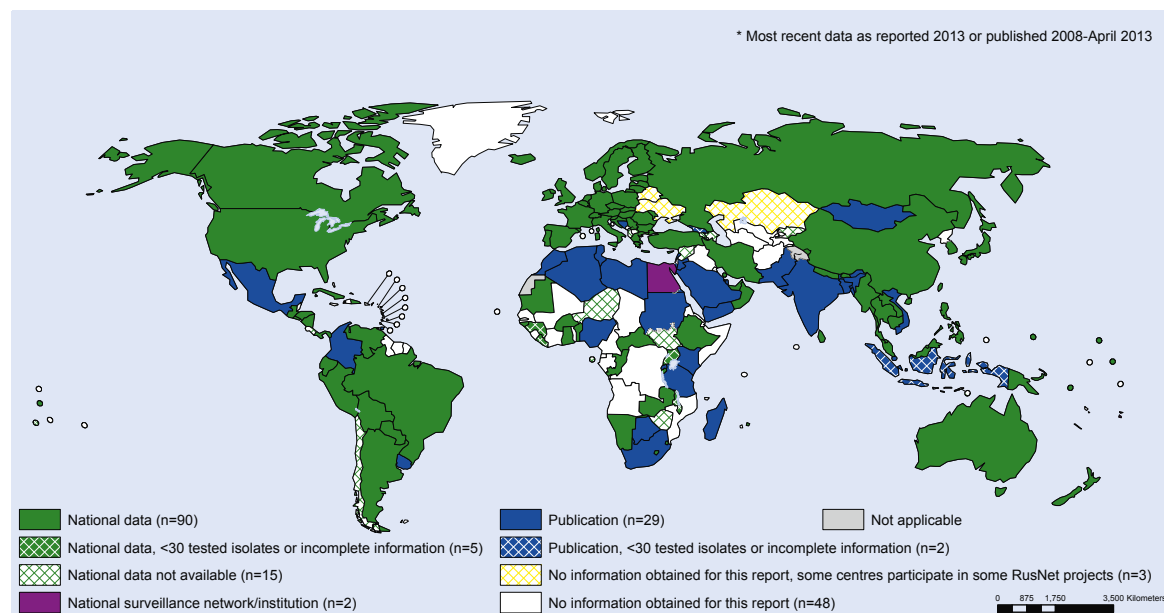
c. Invasive isolates are deep infections, mostly bloodstream infections and meningitis.

d. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

## Resistance to fluoroquinolones in *Escherichia coli*

Figure 4 illustrates sources for obtained resistance data in the countries according to the methods in Annex 1. The major information gaps in national data for *E. coli* resistance to fluoroquinolones were similar to those found for resistance to third-generation cephalosporins.

**Figure 4** Sources of data on *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.7–A2.12, Annex 2).

a. ciprofloxacin; gatifloxacin; levofloxacin; moxifloxacin; norfloxacin; ofloxacin; pefloxacin; rifloxacin; sparfloxacin.

Data obtained from Member States are summarized by WHO region in Table 4, and details at country level are provided in Tables A2.7–A2.12, Annex 2.

**Table 4** *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>

| Data sources based on at least 30 tested isolates <sup>b</sup> | Overall reported range of resistant proportion (%) | Reported range of resistant proportion (%) in invasive isolates <sup>c</sup> (no. of reports) |
|----------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| African Region                                                 |                                                    |                                                                                               |
| – National data (n=14 countries)                               | 14–71                                              | 34–53 (n=2)                                                                                   |
| – Publications (n=23) from 8 additional countries              | 0–98                                               | 0–10 (n=4)                                                                                    |
| Region of the Americas                                         |                                                    |                                                                                               |
| – National data or report to ReLAVRA (n=16 countries)          | 8–58                                               |                                                                                               |
| – Publications (n=5) from 4 additional countries               | 2–60                                               |                                                                                               |
| Eastern Mediterranean Region                                   |                                                    |                                                                                               |
| – National data (n=4 countries)                                | 21–62                                              | 54 (n=1)                                                                                      |
| – Surveillance network <sup>d</sup> , one additional country   | 35                                                 |                                                                                               |
| – Publications (n=32) from 10 additional countries             | 0–91                                               | 15–53 (n=5)                                                                                   |
| European Region                                                |                                                    |                                                                                               |
| – National data or report to EARS-Net (n=35 countries)         | 8–48                                               | 8–47 (n=33)                                                                                   |
| – Publications (n=3) from 2 additional countries               | 0–18                                               | 0–18 (n=2)                                                                                    |
| South-East Asia Region                                         |                                                    |                                                                                               |
| – National data (n=5 countries)                                | 32–64                                              |                                                                                               |
| – Publications (n=19) from 2 additional countries              | 4–89                                               |                                                                                               |
| Western Pacific Region                                         |                                                    |                                                                                               |
| – National data (n=16 countries)                               | 3–96                                               | 7 (n=1)                                                                                       |
| – Institute surveillance (data from 3 hospitals in 1 country)  | 0–14                                               |                                                                                               |
| – Publications (n=5) from 3 additional countries               | 0.2–65                                             | 31 (n=1)                                                                                      |

EARS-Net, European Antimicrobial Resistance Surveillance Network; ReLAVRA, Latin American Antimicrobial Resistance Surveillance Network (For details see Annex 2, Tables A2.7–A2.12).

a. Based on antibacterial susceptibility testing with ciprofloxacin, gatifloxacin, levofloxacin, moxifloxacin, norfloxacin, ofloxacin, pefloxacin, rifloxacin or sparfloxacin. Where the fluoroquinolone was not specified, ciprofloxacin was used.

b. Reported proportions may vary between compound used for testing and some countries report data for several compounds, or data from more than one surveillance system.

c. Invasive isolates are deep infections, mostly bloodstream infections and meningitis.

d. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

The reported resistance to fluoroquinolones generally seemed higher than for the third-generation cephalosporins. Similar to the resistance to the third-generation cephalosporins, there were reports of fluoroquinolone resistance in *E. coli* exceeding 50% in five of the WHO regions.

### Public health implications

High reported proportions of resistance to third-generation cephalosporins means that treatment for severe infections, for which *E. coli* is a likely cause, may need to be initiated with broader therapy (e.g. carbapenems) in these populations. This implies higher costs and stimulus to the expansion of carbapenem-resistant strains. One review of community-acquired neonatal and infant sepsis in developing countries concluded that, because of resistance, a significant proportion of the causal bacteria were treatable neither by the recommended first-line regimen nor by alternative cephalosporin treatment (1).

Quinolones are probably one of the most widely used groups of antibacterial drugs for the treatment of urinary tract infections, of which *E. coli* is the most common cause. Resistance to quinolones may be indicative of resistance to one of the last available oral treatment options in some settings. Data need to be compiled on resistance to other oral antibacterial drugs not included in this report, but which may be useful to treat uncomplicated urinary tract infections (e.g. co-trimoxazole, nitrofurantoin and mecillinam). When oral alternatives are no longer available, treatment by injection may become necessary, with additional costs for the patients and the health systems.

The systematic reviews summarized in Section 3 specifically address the impact on health and economic burden of infections caused by *E. coli* resistant to third-generation cephalosporins and fluoroquinolones. They confirm that patients with infections caused by such resistant *E. coli* strains carry a risk of poorer clinical outcomes and consume more health-care resources than patients with infections by *E. coli* strains susceptible to third-generation cephalosporins or fluoroquinolones.

### Key messages

- Data on *E. coli* resistance to third-generation cephalosporins were obtained from 86 (44%) of the Member States, and on resistance to fluoroquinolones from 92 (47%) of the Member States.
- The collection of reports and publications consistently disclosed high resistance rates to the last generation drugs commonly used to treat serious infections, and to oral drugs used for both community and hospital infections.

### 2.2.2 *Klebsiella pneumoniae* – resistance to third-generation cephalosporins and to carbapenems

Like *E. coli*, bacteria of the genus *Klebsiella* are frequent colonizers of the gut in humans and other vertebrates. Infections with *K. pneumoniae* are particularly common in hospitals among vulnerable individuals such as pre-term infants and patients with impaired immune systems, diabetes or alcohol-use disorders, and those receiving advanced medical care.

Most common are urinary and respiratory tract infections and, in neonates, bloodstream infections. *K. pneumoniae* is a common cause of Gram-negative bloodstream infections. The mortality rates for *K. pneumoniae* hospital-acquired pneumonia depend on the severity of the underlying condition, and can exceed 50% in vulnerable patients, even when treated with appropriate antibacterial drugs.

Like other bacteria in health-care settings *K. pneumoniae* can spread readily between patients, leading to nosocomial outbreaks. This frequently occurs in intensive care units (ITUs) and neonatal care facilities. Spread of *K. pneumoniae* among different hospitals and even across country borders through the transfer of infected or colonized patients has also been documented (2).

### Evolution of antibacterial resistance in *Klebsiella pneumoniae*

Similar to *E. coli*, *K. pneumoniae* acquires resistance to multiple antibacterial drugs mainly through horizontal transfer of mobile genetic elements such as transposons or plasmids. In contrast to *E. coli*, *K. pneumoniae* carries a resistance gene (chromosomally located beta-lactamase) that naturally renders ineffective penicillins with an extended spectrum, such as ampicillin and amoxicillin. Resistance to other widely used and available oral antibacterial drugs such as co-trimoxazole and fluoroquinolones (e.g. ciprofloxacin) has emerged and spread globally. This means that there are few remaining options for oral treatment of *Klebsiella* infections in many parts of the world.

In 1982, the first ESBL was identified during a hospital outbreak of *K. pneumoniae* infections in Germany (3). Since then more than 200 ESBL variants have been identified, some of which have spread rapidly worldwide. Moreover, many ESBL variants initially identified in *K. pneumoniae* have subsequently transferred to *E. coli*. ESBL-positive strains are resistant to all extended beta-lactam antibacterial drugs such as cephalosporins and, for these strains, the carbapenems are the main remaining treatment option.

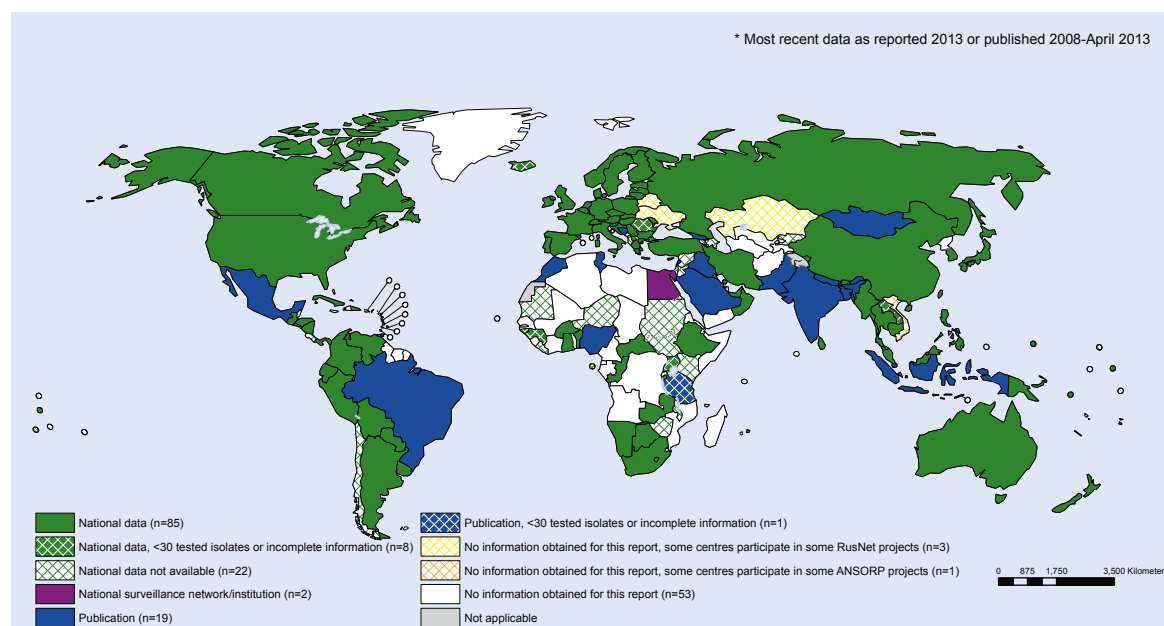
*K. pneumoniae* is also the main cause of infections caused by carbapenem-resistant bacteria worldwide. All of the most important genes that can confer carbapenem resistance (via carbapenemases) are present in *K. pneumoniae*, thereby rendering almost all available treatment options ineffective. For many patients infected with these bacteria there are no clinically effective treatments.

Given the situation outlined above, this report focuses on resistance in *K. pneumoniae* to third-generation cephalosporins, which have been the standard intravenous treatment for severe *Klebsiella* infections in hospitals, and to carbapenems, which are the last option for treatment of severe infections when cephalosporins are no longer reliable due to a high proportion of ESBL-mediated resistance.

### Resistance to third-generation cephalosporins

Figure 5 shows the sources of obtained resistance data in each country, and where major knowledge gaps exist on resistance proportions for *K. pneumoniae* resistant to third-generation cephalosporins.

**Figure 5 Sources of data on *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>**



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.13–A2.18 Annex 2).

a. ceftazidim; cefotaxim; ceftriaxone

Data obtained from Member States are summarized by WHO region in Table 5 (see Tables A2.13–A2.18, Annex 2 for details).

**Table 5** *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup> (summary of reported or published proportions of resistance, by WHO region)

| Data sources based on at least 30 tested isolates <sup>b</sup>                                                                                                                            | Overall reported range of resistant proportion (%) | Reported range of resistant proportion (%) in invasive isolates <sup>c</sup> (no. of reports) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| African Region<br>– National data (n=13 countries)<br>– Publications (n=4) from 1 additional country                                                                                      | 8–77<br>9–69                                       | 41–62 (n=3)                                                                                   |
| Region of the Americas<br>– National data or report to ReLAVRA (n=17 countries)<br>– Publications (n=3) from 3 additional countries                                                       | 4–71<br>15–56                                      | 56 (n=1)                                                                                      |
| Eastern Mediterranean Region<br>– National data (n=4 countries)<br>– Surveillance network <sup>d</sup> (n=1) in 1 additional country<br>– Publications (n=16) from 7 additional countries | 22–50<br>72 (caz)–82 (cro)<br>6–75                 | 48 (n=1)<br>17 (ctx); 43 (caz); 50 (cro) (n=1)                                                |
| European Region<br>– National data or report to EARS-Net (n=33 countries)<br>– Publications (n=2) from 2 additional countries                                                             | 2–82<br>4–61                                       | 2–82 (n=31)<br>11 (cro); 16 (ctx); 18 (caz) (n=1)                                             |
| South-East Asia Region<br>– National data (n=4 countries)<br>– Publications (n=23) from 4 additional countries                                                                            | 34–81<br>5–100                                     | 53.3–100 (n=4)                                                                                |
| Western Pacific Region<br>– National data (n=14 countries)<br>– Institute surveillance (data from 3 hospitals in 1 country)<br>– Publications (n=3) from 2 additional countries           | 1–72<br>17–30<br>27–35                             | 72 (n=1)<br>27 (n=1)                                                                          |

EARS-Net, European Antimicrobial Resistance Surveillance Network; ReLAVRA, Latin American Antimicrobial Resistance Surveillance Network.

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. Reported proportions may vary between compound used for testing and some countries report data for several compounds, or data from more than one surveillance system.

c. Invasive isolates are deep infections, mostly bloodstream infections and meningitis.

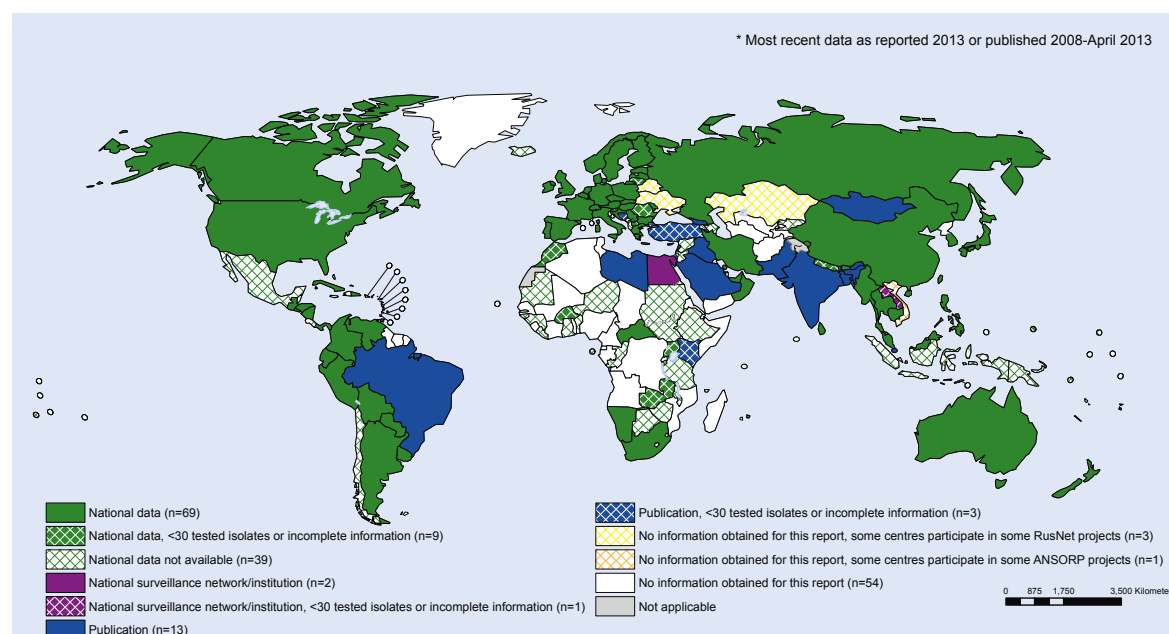
d. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

Reported resistance proportions to third-generation cephalosporins were generally higher in *K. pneumoniae* than in *E. coli*. A majority of sources reported more than 30% resistance in *K. pneumoniae* to third-generation cephalosporins in the sampled populations (Annex 2, Tables A2.13–A2.18). Resistance proportions exceeding 50% were reported from all WHO regions.

### Resistance to carbapenems

Compiled data on carbapenem resistance in *K. pneumoniae* (Figure 6) show knowledge gaps greater than for cephalosporin resistance in *K. pneumoniae*.



**Figure 6** Sources of data on *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>

National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.19–A2.24, Annex 2).

a. doripenem, ertapenem, imipenem, meropenem

Data obtained from Member States are summarized by WHO region in Table 6 (see Annex 2, Tables A2.19–A2.24 for details).

**Table 6** *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup> (summary of reported or published proportions of resistance, by WHO region)

| Data sources based on at least 30 tested isolates <sup>b</sup>                                                                                                                           | Overall reported range of resistant proportion (%) | Reported range of resistant proportion (%) in invasive isolates <sup>c</sup> (no. of reports) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| African Region<br>– National data (n=4 countries)<br>– Publications (n=0)                                                                                                                | 0–4                                                |                                                                                               |
| Region of the Americas<br>– National data or report to ReLAVRA (n=17 countries)<br>– Publications (n=2) from 2 additional countries                                                      | 0–11<br>0–2                                        |                                                                                               |
| Eastern Mediterranean Region<br>– National data (n=4 countries)<br>– Surveillance network <sup>d</sup> (n=1) in 1 additional country<br>– Publications (n=9) from 5 additional countries | 0–54<br>6<br>0–21                                  | 54 (n=1)<br>0 (n=1)                                                                           |
| European Region<br>– National data or report to EARS-Net (n=31 countries)<br>– Publications (n=3) from 2 additional countries                                                            | 0–68<br>2–7                                        | 0–68 (n=30)<br>2 (n=1)                                                                        |
| South-East Asia Region<br>– National data (n=4 countries)<br>– Publications (n=15) from 2 additional countries                                                                           | 0–8<br>0–55                                        | 0–52 (n=3)                                                                                    |
| Western Pacific Region<br>– National data (n=9 countries)<br>– Institute surveillance (data from 2 hospitals in 1 country)<br>– Publications (n=2) from 2 additional countries           | 0–8<br>0–1<br>0–11                                 |                                                                                               |

EARS-Net, European Antimicrobial Resistance Surveillance Network; PAHO, Pan American Health Organization; ReLAVRA, Latin American Antimicrobial Resistance Surveillance Network.

a. Based on antibacterial susceptibility testing with doripenem, ertapenem, imipenem or meropenem

b. Reported proportions may vary between compound used for testing and some countries report data for several compounds, or data from more than one surveillance system.

c. Invasive isolates are deep infections, mostly bloodstream infections and meningitis.

d. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.



As can be seen in the table, carbapenem-resistant *K. pneumoniae* has now been reported in all WHO regions, with reports in two regions exceeding 50%. There are gaps in information in most WHO regions, because 49 of the 69 datasets came from countries in the Region of the Americas and the European Region.

### Public health implications

As for *E. coli* resistant to third-generation cephalosporins, the high proportions of cephalosporin resistance means that treatment for verified or suspected severe *K. pneumoniae* infections in many situations has to rely on carbapenems, if available. This usually involves higher costs and a risk of further expansion of carbapenem-resistant strains. At the same time, and as for *E. coli*, there is a risk that findings based on limited series of skewed patient groups may lead to unnecessarily high usage of broad-spectrum antibacterial drugs, which will exacerbate the resistance problem. Of even greater concern is that infections with carbapenem-resistant strains need to be treated with the last-resort drugs tigecycline or colistin, which are not only less effective but also not widely available.

The systematic review summarized in Section 3 addressed the impact on health and economic burden due to infections caused by *K. pneumoniae* resistant to third-generation cephalosporins and carbapenems. The review confirms that patients with such resistant *K. pneumoniae* infections carry a risk of worse clinical outcomes and consume more health-care resources than patients infected by susceptible strains.

### Key messages

- Data on resistance to third-generation cephalosporins were obtained from 87 (45%) of the Member States, and on carbapenem resistance from 71 (37%) of the Member States. Most of the reporting countries are in two WHO regions – Region of the Americas and the European Region – revealing large gaps in knowledge in most parts of the world (including in several non-EU countries in the European Region).
- A majority of sources reported more than 30% resistance in *K. pneumoniae* against third-generation cephalosporins, and some countries more than 60%.
- Alarming rates of carbapenem resistance – exceeding 50% – have been reported in *K. pneumoniae* in some patient groups, for which few if any alternative treatment options are available.

### 2.2.3 *Staphylococcus aureus* – resistance to methicillin

*S. aureus* is a Gram-positive bacterium that can be a part of the normal flora on the skin and in the nose, but is another of the most important human pathogens. *S. aureus* can cause a variety of infections, most notably skin, soft tissue, bone and bloodstream infections. It is also the most common cause of postoperative wound infections. Some strains of *S. aureus* produce toxic factors that can cause a variety of specific symptoms, including toxic shock syndrome and food poisoning.

#### Evolution of antibacterial resistance in *Staphylococcus aureus*

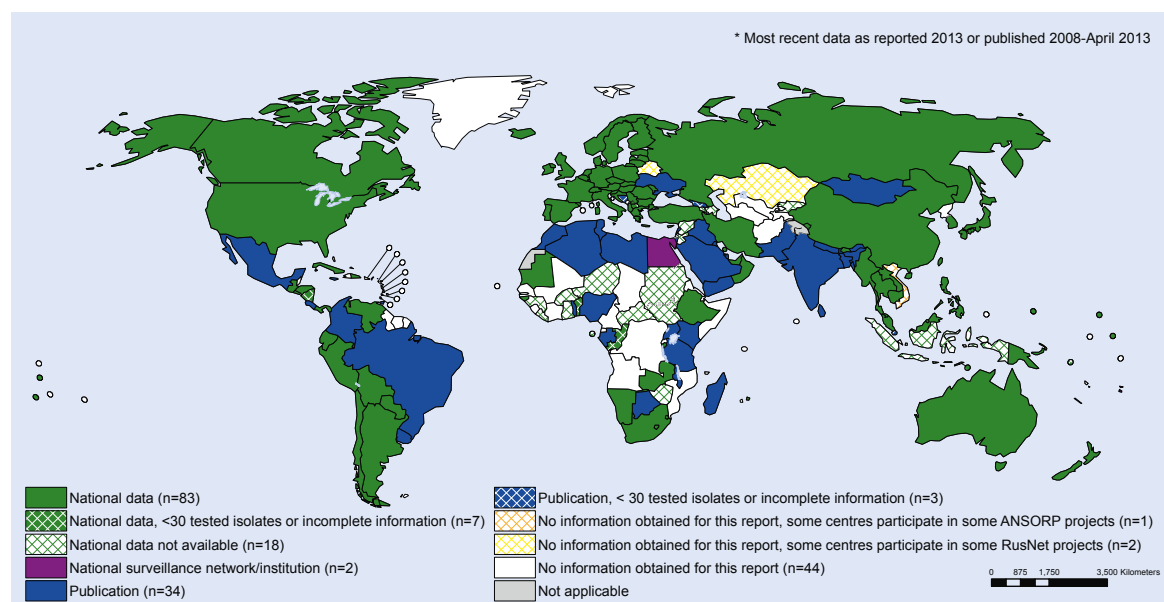
When penicillin was first introduced it was an effective treatment for *S. aureus* infections, but resistance had already developed during the 1940s. This resistance was mediated by the production of a beta-lactamase enzyme that inactivates drugs such as penicillin, ampicillin and amoxicillin. Consequently, beta-lactamase-stable drugs (e.g. methicillin and cloxacillin) as well as beta-lactamase inhibitors (e.g. clavulanic acid and sulbactam) that could be combined with the antibacterial drugs were developed. Strains of *S. aureus* resistant to these penicillinase-stable antibacterial drugs have acquired a novel gene (*mecA*) that codes for a novel penicillin-binding protein; these strains are termed methicillin-resistant *Staphylococcus aureus* (MRSA).

The first strains of MRSA emerged during the 1960s. Initially, MRSA was mainly a problem in hospital-acquired infections. Over the past decade, community-acquired MRSA has increased significantly in a number of countries. Fortunately, many of these community-acquired MRSA strains have so far retained susceptibility to a number of non-beta-lactam antimicrobials, whereas most health-care associated MRSA infections are caused by difficult-to-treat multiresistant strains. For the latter, the treatment of last resort has been glycopeptides such as vancomycin (since the 1950s) and teicoplanin, which can only be given by injection and also needs careful monitoring to avoid adverse side-effects. New treatment options for MRSA (but also associated with problematic side-effects) have been developed more recently: linezolid (1970s) and daptomycin (1980s) are the most recently licensed antibacterial drug classes.

## Methicillin resistance in *Staphylococcus aureus*

Figure 7 shows the sources of resistance data in each country according to the methods in Annex 1, and the major knowledge gaps for MRSA proportions in *S. aureus*, based on the data available for this report.

**Figure 7** Sources of data on *Staphylococcus aureus*: Resistance to beta-lactam antibacterial drugs (i.e. methicillin-resistant *S. aureus*, MRSA)



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.25–A2.30, Annex 2).

Data obtained from Member States are summarized by WHO region in Table 7. Details at the country level are in Annex 2, Tables A2.25–A2.30.

**Table 7** *Staphylococcus aureus*: Resistance to beta-lactam antibacterial drugs (i.e. methicillin-resistant *S. aureus*, MRSA)

| Data sources based on at least 30 tested isolates <sup>a</sup>                                                                                                                           | Overall reported range of resistant proportion (%) | Reported range of resistant proportion (%) in invasive isolates <sup>b</sup> (no. of reports) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| African Region<br>– National data (n=9 countries)<br>– Publications (n=27) from 10 additional countries                                                                                  | 12–80<br>0–100                                     | 52 (n=1)<br>33–95 (n=3)                                                                       |
| Region of the Americas<br>– National data or report to ReLAVRA (n=15 countries)<br>– National networks (n=2) no additional country<br>– Publications (n=17) from 7 additional countries  | 21–90<br>21–84<br>2.4–90                           | 43–45 (n=2)                                                                                   |
| Eastern Mediterranean Region<br>– National data (n=4 countries)<br>– Hospital network <sup>c</sup> (n=1) from 1 additional country<br>– Publications (n=31) from 10 additional countries | 10–53<br>46<br>0–92                                | 53 (n=1)<br>13–18 (n=3)                                                                       |
| European Region<br>– National data or report to EARS-Net n=36 countries)<br>– Publications (n=5) from 2 additional countries                                                             | 0.3–60<br>27–80                                    | 0.3–6 (n=32)<br>27–50 (n=3)                                                                   |
| South-East Asia Region<br>– National reports (n=3 countries)<br>– Publications (n=25) from 4 additional countries                                                                        | 10–26<br>2–81                                      | 37 (n=1)                                                                                      |
| Western Pacific Region<br>– National data (n=16 countries)<br>– Institute surveillance (n=2 from one additional country)<br>– Publications (n=1) from one additional country             | 4–84<br>1–4<br>60                                  |                                                                                               |

EARS-Net; European Antimicrobial Resistance Surveillance Network; ReLAVRA, Latin American Antimicrobial Resistance Surveillance Network.

a. Some countries report data from more than one surveillance system.

b. Invasive isolates are deep infections, mostly bloodstream infections and meningitis.

c. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

## Public health implications

The implication of high reported proportions of MRSA is that treatment for suspected or verified *S. aureus* infections in many countries may require second-line antibacterials. This may also be the case for prophylaxis in orthopaedic and many other surgical procedures. Second-line drugs needed to treat or prevent MRSA infections are more expensive and, because of their side-effects, monitoring during treatment is advisable. As for the other bacteria, however, there is a risk that empiric treatment recommendations based on small and skewed patient samples may lead to an unnecessary overuse of more expensive second-line drugs.

The systematic reviews summarized in Section 3 address the impact on health and economic burden from infections caused by MRSA. The available evidence discloses a clear increase in mortality and use of health-care resources, and therefore additional costs, associated with MRSA.

## Key messages

- Data on MRSA proportions among *S. aureus* were obtained from 85 (44%) of the Member States.
- Most reported MRSA proportions exceed 20% in all WHO regions, and even exceed 80% in some reports.
- High MRSA proportions imply increased risk for patients and a need for second-line more toxic drug treatment. This will increase costs and side-effects, and may drive resistance further in staphylococci or other species (or both).

## 2.2.4 *Streptococcus pneumoniae* – resistance (non-susceptibility) to penicillin

*S. pneumoniae* (the bacteria are also known as pneumococci) is the leading cause worldwide of community-acquired pneumonia, which is among the main killers of children under 5 years of age. Other diseases caused by *S. pneumoniae* include common mild, self-limiting infections such as acute otitis media, but also extend to cases of invasive disease with high mortality such as meningitis. Among the bacterial causes of meningitis, *S. pneumoniae* is associated with the highest case-fatality rate and is the most likely to leave survivors with permanent residual symptoms.

The clinical burden of pneumococcal infection is concentrated among the eldest and youngest sections of the population. According to one estimate, *S. pneumoniae* caused about 826 000 deaths (582 000–926 000) in children aged 1–59 months. For HIV-negative children pneumococcal infection corresponds to 11% of all deaths in this age group (4). Pneumococci are commonly found in asymptomatic nasopharyngeal carriage, where the prevalence varies by age and region. The asymptomatic carriage state is responsible for much of the transmission within populations, such as day-care centres.

## Evolution of antibacterial resistance in *Streptococcus pneumoniae*

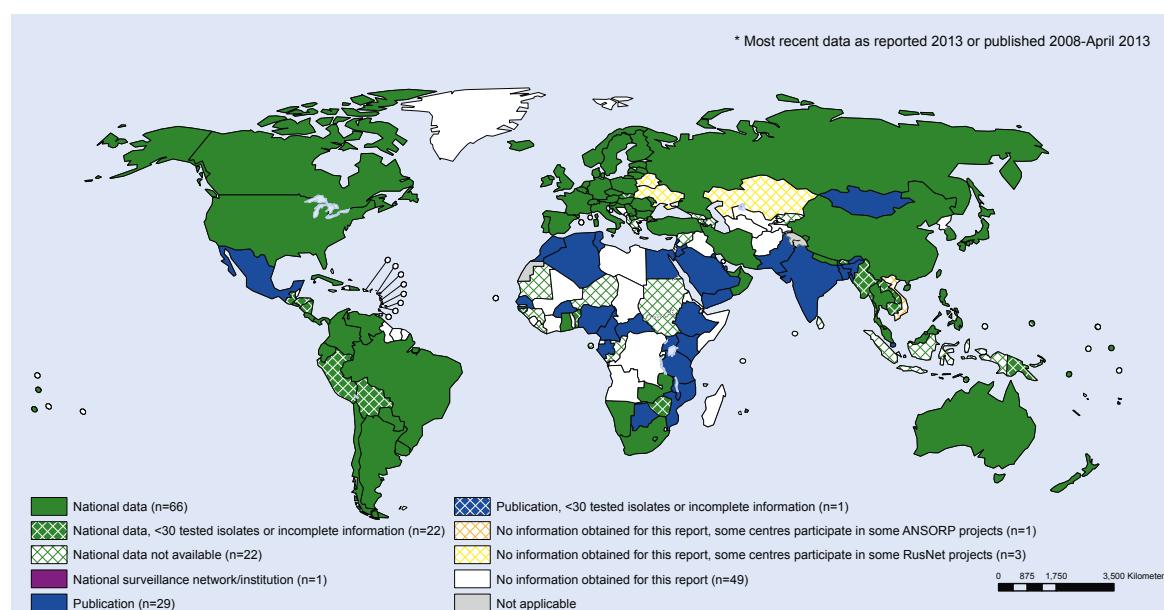
Resistance to beta-lactam antibacterial drugs in clinical isolates of *S. pneumoniae* occurs through the acquisition of mutations in the genes coding for the penicillin-binding proteins (PBPs), essential components of the bacterial cell wall. The successive acquisition of multiple mutations in the different PBPs results in increasing minimum inhibitory concentrations (MICs) for penicillin and the other beta-lactam drugs. The methodology needed to detect this gradual increased resistance and characterize as “non-susceptible” (NS) or “resistant” (R) is different; thus, it is reported differently from different sources, depending on the capacity the sources have.

As for the other bacteria considered in this report, some particularly successful strains have emerged and rapidly spread worldwide.

## Resistance and reduced susceptibility to penicillin in *Streptococcus pneumoniae*

Figure 8 shows the sources of collected data on non-susceptibility or resistance to penicillin in *S. pneumoniae* in each country, and that there were larger gaps in the available resistance data for this typically community-acquired pathogen, compared to the bacteria–antibacterial drug combinations described previously.

**Figure 8** Sources of data on *Streptococcus pneumoniae*: Resistance or non-susceptibility to penicillin



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.31–A2.36, Annex 2).

Data obtained from Member States are summarized by WHO region in Table 8. Details at the country level are in Annex 2, Tables A2.31–A2.36.

**Table 8** *Streptococcus pneumoniae*: Resistance or non-susceptibility to penicillin

| Data sources based on at least 30 tested isolates                                                                                                              | Overall reported range of proportion resistant (R) and/or non-susceptible (NS) | Reported range of proportion resistant or non-susceptible in invasive isolates <sup>a</sup> (no. of reports) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| African Region<br>– National data (n=5 countries)<br>– Publications (n=16) from 14 additional countries                                                        | 3–16 (R) or 57–60 (NS)<br>1–100 (R) or 9–69 NS or 0–79 <sup>b</sup>            | 3 (R) (n=1)<br>9–18 (NS) or 24–79 <sup>b</sup> (n=5)                                                         |
| Region of the Americas<br>– National data or report to ReLAVRA or SIREVA (n=15 countries)<br>– Publications (n=1) from 1 additional country                    | 0–48 <sup>b</sup><br>53 (non-meningitis) (NS)                                  | 0–48 <sup>b</sup> (n=14)<br>64 (meningitis) (NS)                                                             |
| Eastern Mediterranean Region<br>– National data (n=3 countries)<br>– Publications (n=17) from 9 additional countries                                           | 13–34 (R) or 5 (NS)<br>0.3–64 (R) or 17–48 (NS) or 0–93 <sup>b</sup>           | 34 (R) (n=1)<br>2–14 (R) or 17–40 (NS) (n=10)                                                                |
| European Region<br>– National data or report to EARS-Net (n=31 countries)<br>– Publications (n=1) from 1 additional country                                    | 0–61 (R) or 0.9–73 (NS)<br>13–68 (NS)                                          | 0.9–61 (NS) or 32–45 <sup>b</sup> (n=27)<br>13 (NS) (n=1)                                                    |
| South-East Asia Region<br>– National data (n=2 countries)<br>– Publications (n=2) from 2 additional countries                                                  | 47–48 <sup>b</sup><br>0–6 (R)                                                  | 0 (R) (n=1)                                                                                                  |
| Western Pacific Region<br>– National data (n=10 countries)<br>– Hospital data (two hospitals in 1 country)<br>– Publications (n=4) from 2 additional countries | 17–64 (NS) or 0–47 <sup>b</sup><br>0–2<br>44–96 (R) or 0–69 (NS)               | 44 (R) or 0 (NS) (n=2)                                                                                       |

EARS-Net, European Antimicrobial Resistance Surveillance Network; NS, non-susceptible; R, resistant; ReLAVRA, Latin American Antimicrobial Resistance Surveillance Network; SIREVA, Sistema de Redes de Vigilancia de los Agentes Responsables de Neumonías y Meningitis Bacterianas (System of Networks for Surveillance of the Bacterial Agents Responsible for Pneumonia and Meningitis).

(for details see Annex 2, Table A2.31–A2.36)

a. Invasive isolates are deep infections, mostly bloodstream infections and meningitis.

b. Not specified whether R or NS.

Of the countries providing data sets on at least 30 tested isolates, 57 came from three WHO regions – Region of the Americas, the European Region and the Western Pacific Region – leaving major gaps in data from the other regions.

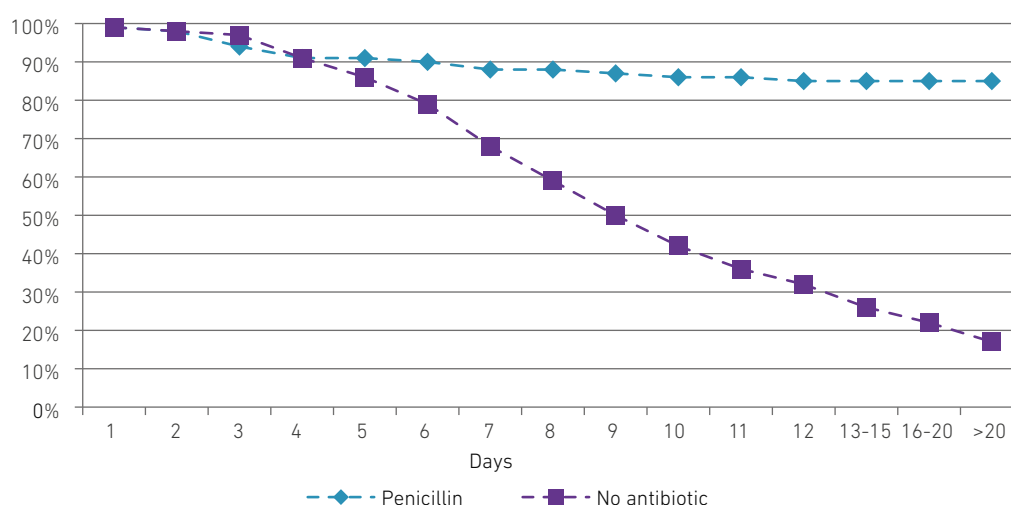
Compilation of data was complicated by differences in the terminology and microbiological methods used in the different data sources. Results may be presented in different categories: resistant (R); non-susceptible (NS), which includes resistant plus reduced susceptibility; or susceptible (S), which refers to those that are not NS. It is likely that this classification may not be

interpreted or applied identically by all laboratories. Despite discrepancies, non-susceptibility to penicillin is detected in all WHO regions, and exceeds 50% in reports based on some types of samples.

### Public health implications

When penicillin was introduced, it dramatically changed the outcome for patients with pneumococcal pneumonia and concomitant bloodstream infection (which is common) from a case-fatality rate of about 90% to a survival rate of about 90% (Figure 9).

**Figure 9 Survival after pneumococcal pneumonia with bloodstream infection before and after penicillin treatment became available.**



Adapted from Austrian et al. (5).

Resistance has been linked to worse clinical outcomes in patients with pneumococcal meningitis, but the clinical implications for patients with bloodstream infections caused by *S. pneumoniae* strains with reduced susceptibility to penicillin are less clear (6-9). Nevertheless, resistance data may influence treatment guidelines for bloodstream infections, entailing increased health-care costs that may not always be justified. Thus, more data on resistance would be valuable. However, and as mentioned previously, to distinguish R from NS requires different methodologies and would need increased laboratory capacity for conducting AST.

### Key messages

- Data were obtained from only 67 (35%) of the Member States. The major gaps in surveillance of this important, typically community-acquired pathogen, according to the data compiled for this report, were in three WHO regions: the African Region, the Eastern Mediterranean Region and the South-East Asia Region.
- Non-susceptibility to penicillin has been detected in all WHO regions.

- Differences between microbiological methods and in terminology for reporting resistance add to difficulties in assessing the magnitude of the impact of resistance on disease burden and clinical outcomes.

### 2.2.5 Nontyphoidal *Salmonella* – resistance to fluoroquinolones

Bacteria of the genus *Salmonella* are a major cause of foodborne illness throughout the world. As a zoonotic pathogen, *Salmonella* can be found in the intestines of many food-producing animals such as poultry and pigs. Infection is usually acquired by consumption of contaminated water or food of animal origin: mainly undercooked meat, poultry, eggs and milk. Human or animal faeces can also contaminate the surface of fruits and vegetables, which can lead to foodborne outbreaks.

Most *Salmonella* strains cause gastroenteritis, while some strains, particularly *Salmonella enterica* serotypes Typhi and Paratyphi, are more invasive and typically cause enteric fever. Enteric fever is a more serious infection that poses problems for treatment due to ABR in many parts of the world.

This report focuses on nontyphoidal *Salmonella* (NTS), because these are main diarrhoeal pathogens transmitted via the food chain. In many countries, the incidence of NTS infections has increased markedly in recent years, for reasons that are unclear. One estimate suggests that there are around 94 million cases, resulting in 155 000 deaths, of NTS gastroenteritis each year. The majority of the disease burden, according to this study, is in the South-East Asian Region and the Western Pacific Region (10).

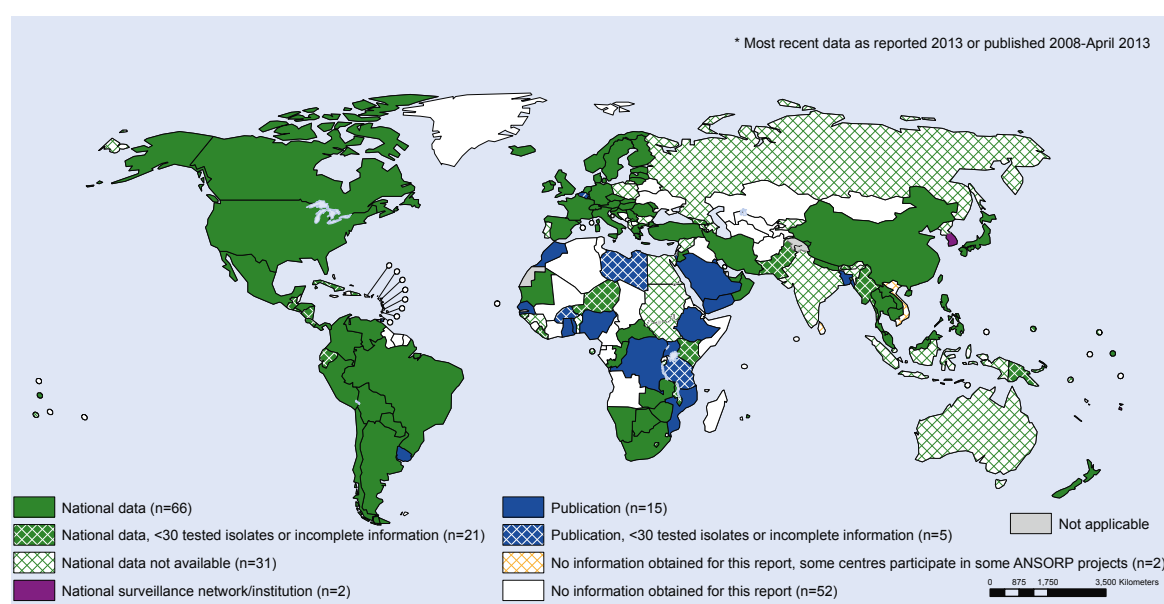
### Evolution of antibacterial resistance in nontyphoidal *Salmonella*

ABR varies between different serotypes of NTS, and is significant in some of them. During the late 1990s and early 2000s, several clones of multidrug-resistant *Salmonella* emerged, and since then they have expanded worldwide. For instance, in *Salmonella enterica* serotype Typhimurium, the genomic element that carries resistance to five antimicrobials (ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracycline) may spread horizontally among other serotypes and acquire additional resistance determinants.

### Resistance to fluoroquinolones in nontyphoidal *Salmonella*

Figure 10 shows the sources of collected resistance data in each country according to the methods in Annex 1, and notes where there are major knowledge gaps for resistance to fluoroquinolones in NTS, based on the data available for this report. Comparatively little information was available on this community-acquired pathogen from African and Asian countries.

**Figure 10** Sources of data on nontyphoidal *Salmonella*: Resistance to fluoroquinolones<sup>a</sup>



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.37–A2.42, Annex 2).

a. ciprofloxacin, norfloxacin.

Data obtained from Member States are summarized by WHO region in Table 9, and details at country level are given in Tables A2.37–A2.42, Annex 2.



**Table 9 Nontyphoidal *Salmonella*: Resistance to fluoroquinolones<sup>a</sup> (summary of reported or published proportions of resistance, by WHO region)**

| Data sources based on at least 30 tested isolates                                                                                                               | Overall reported range of resistant proportion (%) | Reported range of resistant proportion (%) in blood isolates (no. of reports) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------|
| African Region<br>– National data (n=9 countries)<br>– Publications (n=11) from 8 additional countries                                                          | 0–35<br>0–30                                       | 0–30 (n=4)                                                                    |
| Region of the Americas<br>– National data (n=13 countries)<br>– Publications (n=1) from 1 additional country                                                    | 0–96<br>0                                          |                                                                               |
| Eastern Mediterranean Region<br>– National data (n=4 countries)<br>– Publications (n=4) from 4 additional countries                                             | 2–49<br>0–46                                       | 6 (n=1)                                                                       |
| European Region<br>– National data or report to FWD-Net, (n=29 countries)<br>– Publications (n=1) from 1 additional country                                     | 2–3<br>13                                          |                                                                               |
| South-East Asia Region<br>– National data (n=2 countries)<br>– Publication (n=1) from 1 additional country                                                      | 0.2–4<br>1.4                                       |                                                                               |
| Western Pacific Region<br>– National data (n=9 countries)<br>– Network/institution data (n=4 from 2 countries)<br>– Publications from remaining countries (n=0) | 0–14<br>0–0.3                                      |                                                                               |

FWD-Net, Foodborne and Waterborne Diseases and Zoonoses Network.

a. ciprofloxacin, norfloxacin.

Some of the information gaps were in the South-East Asian and Western Pacific Regions, where the disease burden has been estimated to be highest (10). The resistance in NTS to fluoroquinolones was less than 5% in a majority of national data, although there were some from the African Region and the Eastern Mediterranean Region of 35%–49% and one from Region of the Americas of 96%. A possible imprecision in the definition of the term NTS (and therefore of which results should be included), and the inclusion of only a subset of *Salmonella* types in some reports, probably contributed to this observed variation in resistance proportions.

### Public health implications

Infections caused by NTS are common and usually self-limiting. In severe cases antibacterial treatment may be warranted. Multidrug-resistant *Salmonella enterica* serotype Typhimurium has been associated with a higher risk of invasive infection, higher frequency and duration of hospitalization, longer illness, and increased risk of death as compared to infections caused by susceptible strains (11). Reduced susceptibility to oral drugs such as ciprofloxacin, and increasing numbers of treatment failures, are of concern.

### Key messages

- Data on resistance in NTS to fluoroquinolones were obtained from 68 (35%) of the Member States. Some of the major information gaps were in regions

where the disease burden is highest, such as in South-East Asia.

- Reported resistance was less than 5% in most of the reporting countries: a low proportion that may be partly attributable to differing interpretation of the definition of the *Salmonella* serotypes to be included. Thus, the data should be interpreted with caution.

### 2.2.6 *Shigella* species – resistance to fluoroquinolones

*Shigella* species are a major cause of diarrhoea and dysentery throughout the world. These bacteria are transmitted by ingestion of contaminated food or water, or through person-to-person contact. Shigellosis is primarily a disease of resource-poor crowded communities that do not have adequate sanitation or safe water. *Shigella* is never considered to be part of the normal intestinal flora. Ingestion of just a few of these organisms is enough to result in development of symptoms. Most patients recover without complications within 7 days, but shigellosis can be a life-threatening or fatal disease, particularly in children. The annual number of *Shigella* episodes worldwide is estimated to be 165 million, of which more than 100 million occur in the developing world, causing more than 1 million deaths. The highest rate of *Shigella* infection (69% of cases) and the highest death rate (61% of deaths) occur in those younger than 5 years (12–14).

## Evolution of antibacterial resistance in *Shigella*

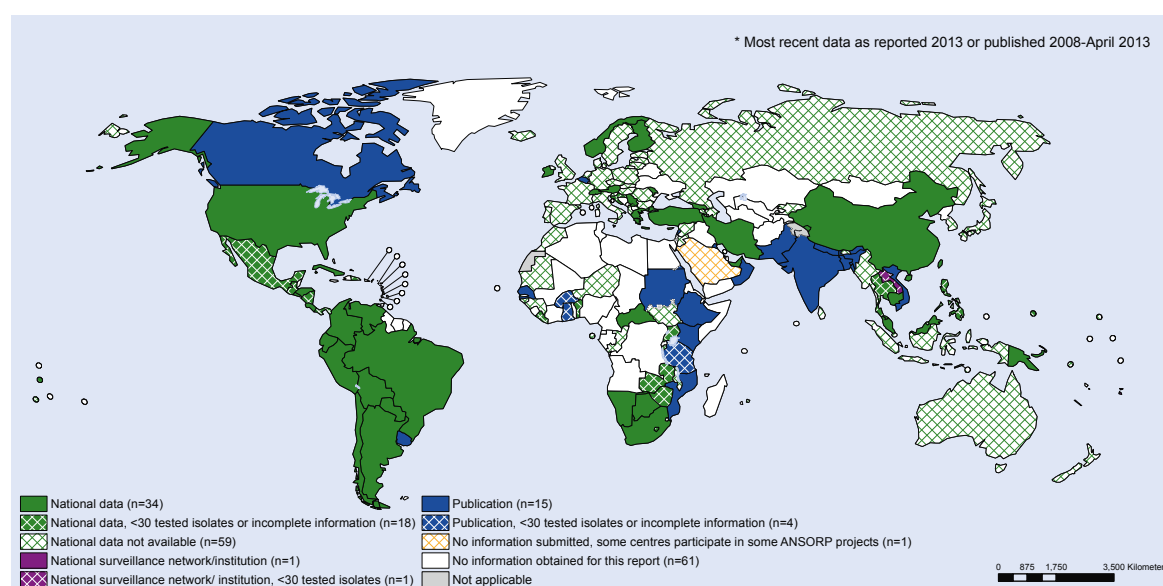
Formerly, *Shigella* strains were susceptible to co-trimoxazole. However, as resistance has emerged to this antimicrobial, treatment recommendations have shifted

to ciprofloxacin or azithromycin. Mobile genetic units (including plasmids, gene cassettes in integrons and transposons) are important in the spread of resistance determinants among *Shigella* isolates, as well as in other enterobacteria such as *Klebsiella* and *E. coli*.

## Resistance to fluoroquinolones in *Shigella* species

Figure 11 shows the sources of collected resistance data in each country according to the methods in Annex 1.

**Figure 11** Sources of data on *Shigella* species, resistance to fluoroquinolones<sup>a</sup>



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.43–A2.48, Annex 2).

a. ciprofloxacin, norfloxacin.

Data obtained from Member States are summarized by WHO region in Table 10, see Tables A2.43–A2.48, Annex 2 for details.

**Table 10** *Shigella* species: Resistance to fluoroquinolones<sup>a</sup>

| Data sources based on at least 30 tested isolates        | Overall reported range of resistant proportion (%) |
|----------------------------------------------------------|----------------------------------------------------|
| African Region                                           |                                                    |
| – National data (n=4 countries)                          | 0–3                                                |
| – Publications (n=8) from 4 additional countries         | 0–9                                                |
| Region of the Americas                                   |                                                    |
| – National data (n=14 countries)                         | 0–8                                                |
| – Publications (n=2) from 2 additional countries         | 0–20                                               |
| Eastern Mediterranean Region                             |                                                    |
| – National data (n=2 countries)                          | 3–10                                               |
| – Publications (n=7) from 5 additional countries         | 0–41.3                                             |
| European Region                                          |                                                    |
| – National data or reports to FWD-Net (n=10 countries)   | 0–47                                               |
| – Publications (n=2) from 1 additional country           | 0                                                  |
| South-East Asia Region                                   |                                                    |
| – National data (n=0 countries)                          |                                                    |
| – Publications (n=11) from 3 additional countries        | 0–82                                               |
| Western Pacific Region                                   |                                                    |
| – National data (n=4 countries)                          | 3–28                                               |
| – Network/ institution data (two hospitals in 1 country) | 0                                                  |
| – Publications (n=1) from 1 additional country           | 2                                                  |

FWD-Net, Foodborne and Waterborne Diseases and Zoonoses Network (coordinated by the ECDC).

a. ciprofloxacin, norfloxacin.



Except in AMRO, national data were generally scarce, especially from countries where shigellosis is a significant public health problem, particularly in children (12–14). Most reporting countries reported resistance proportions below 10%, although a proportion of 82% was reported by one country. More information on the situation is needed.

### Public health implications

Antibacterial drugs have a proven effect in the management of *Shigella* infections and may be life-saving. Emerging resistance has been reported as a concern from some countries. For this reason, the gaps in surveillance data at national level are of concern and raise the question as to whether or not representative local data are available to also inform treatment guidelines.

### Key messages

- Data were obtained from only 35 (18%) of the Member States, with gaps in knowledge about resistance in *Shigella* species in countries where the major disease burden is.
- Better understanding of the frequency and patterns of resistance in *Shigella* species could inform treatment policy-making for reduction of disease burden and mortality.

### 2.2.7 *Neisseria gonorrhoeae* – decreased susceptibility to third-generation cephalosporins

*N. gonorrhoeae* is the bacterium that causes gonorrhoea (the bacteria are also known as gonococci). Gonorrhoea is a sexually transmitted, acute infection of the reproductive tract that may be symptomatic or asymptomatic. If untreated, or inappropriately treated, this infection can result in severe complications, including genital and reproductive tract inflammation and damage, and infertility. *N. gonorrhoeae* can also be transmitted sexually to infect other anatomic sites such as the pharynx and the rectum. Infection in pregnant women can result in infections in the newborn, including eye infections that may lead to blindness. The most recent WHO estimates from 2008 suggested that there were 106 million new cases of gonorrhoea in adults aged 15–49 years globally (15).

### Evolution of antibacterial resistance in *Neisseria gonorrhoeae*

The history of emergence of ABR in gonococci has followed the same general pattern for many decades; the release of each new class of antibacterial drugs for the treatment of gonorrhoea has been followed by the development of resistance to it. This acquired resistance has expanded globally and been sustained over time, persisting even after the specific antibacterial drug has been withdrawn from the market.

The emergence of gonococcal resistance to penicillin and tetracycline was identified in Asia during the 1970s, and became widespread in multiple regions in the early 1980s. In the early to mid-1990s, high levels of resistance to fluoroquinolones also emerged in Asia and started to spread internationally. The third-generation cephalosporins, which are the last remaining options for empiric monotherapy, are now recommended as the first-line treatment regimen for gonococcal infections (in the USA and Europe in a dual antimicrobial regimen, generally combined with azithromycin) (16, 17). There is no ideal alternative to the third-generation cephalosporins, and there are very few new treatment options in the drug development pipeline.

In this context, alarmingly, several countries have reported treatment failures with oral cephalosporin (cefixime), and there are now some verified reports of treatment failure with the parenteral cephalosporin (ceftriaxone) in patients with pharyngeal gonorrhoea (18). The gonococcal strains causing those clinical failures were resistant to most other antibacterial drugs relevant for treatment, and have been classified as multidrug-resistant gonococci or even extensively drug-resistant gonococci.

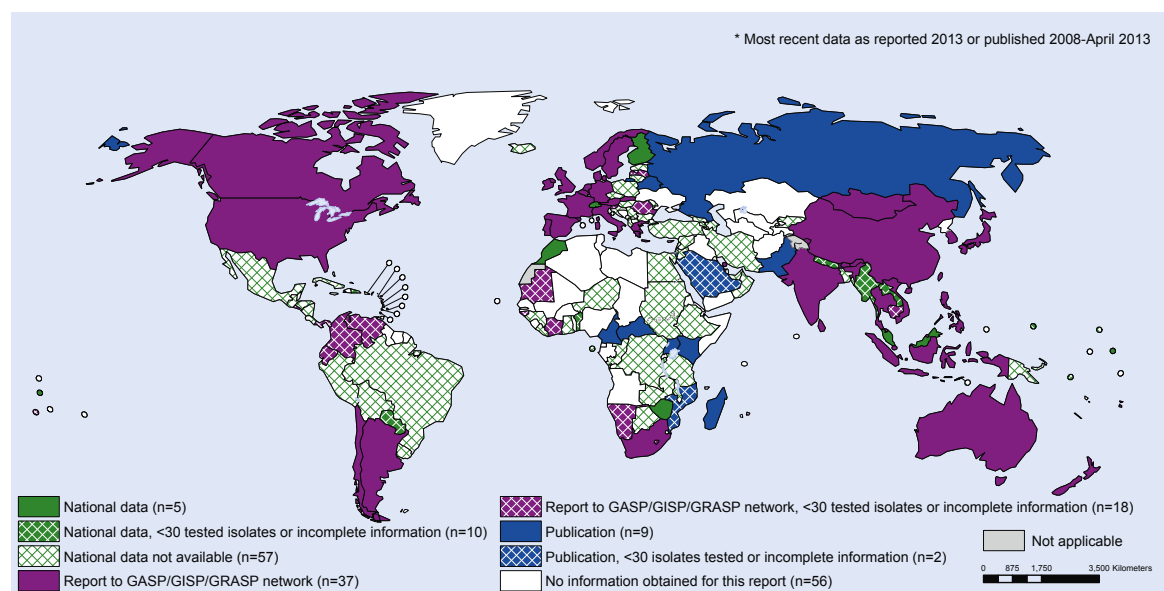
### Surveillance of decreased susceptibility to third-generation cephalosporins in *N. gonorrhoeae*

The WHO Gonococcal Antimicrobial Surveillance Programme (GASP) was established in 1992 in the Western Pacific Region, and since then a global laboratory network has been developed to coordinate gonococcal antimicrobial resistance surveillance, monitor longitudinal trends in antimicrobial resistance and provide data to inform treatment guidelines. In each WHO region there is a GASP coordinating laboratory that works in partnership with the corresponding WHO regional office. The regional coordinating laboratory provides technical support to countries to strengthen laboratory capacity, and an external quality assessment programme including maintenance and distribution of the WHO panels of *N. gonorrhoeae* reference strains for quality assurance (19). In high-income countries, the widespread adoption of molecular methods for detecting *N. gonorrhoeae* has reduced the number of specimens being cultured, therefore decreasing the number of isolates undergoing AST.

When considering and interpreting data it must be noted that the GASP reporting laboratories use a number of different methods of AMR testing and there are important differences in these methods, in particular for the reporting of ceftriaxone. Although the issue of comparability remains unresolved, the use of WHO *N. gonorrhoeae* control strains in testing, and the WHO Global Action Plan (20), which in 2012 suggested the level for decreased susceptibility for ceftriaxone, have somewhat improved the situation.

Figure 12 shows the sources of collected resistance data in each country according to the methods in Annex 1. In situations where data were obtained from more than one national data source (n=3 for which data on >30 isolates were obtained and n=1 providing data on < 30 isolates), the priority was given to illustrating country participation in the WHO GASP/Gonococcal Isolate Surveillance Project (GISP)/Gonococcal Resistance to Antimicrobials Surveillance Programme (GRASP) network in the map. The number of countries participating in GASP varies by region, as does the extent to which those countries perform gonococcal resistance surveillance.

**Figure 12 Sources of data on *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>**



National data refers to requested data returned as described in the methods. The definition does not imply that the data collected are representative for that country as a whole because information gaps are likely. (For details on data see Tables A2.31–A2.36, Annex 2).

a. ceftriaxone, cefixim.

Data obtained from Member States reporting data via the GASP/GISP/GRASP network, or via the questionnaire, are summarized by WHO region in Table 11. (See Table A2.49–A2.54, Annex 2 for details).

**Table 11 *Neisseria gonorrhoeae*: decreased susceptibility to third-generation cephalosporins<sup>a</sup>**

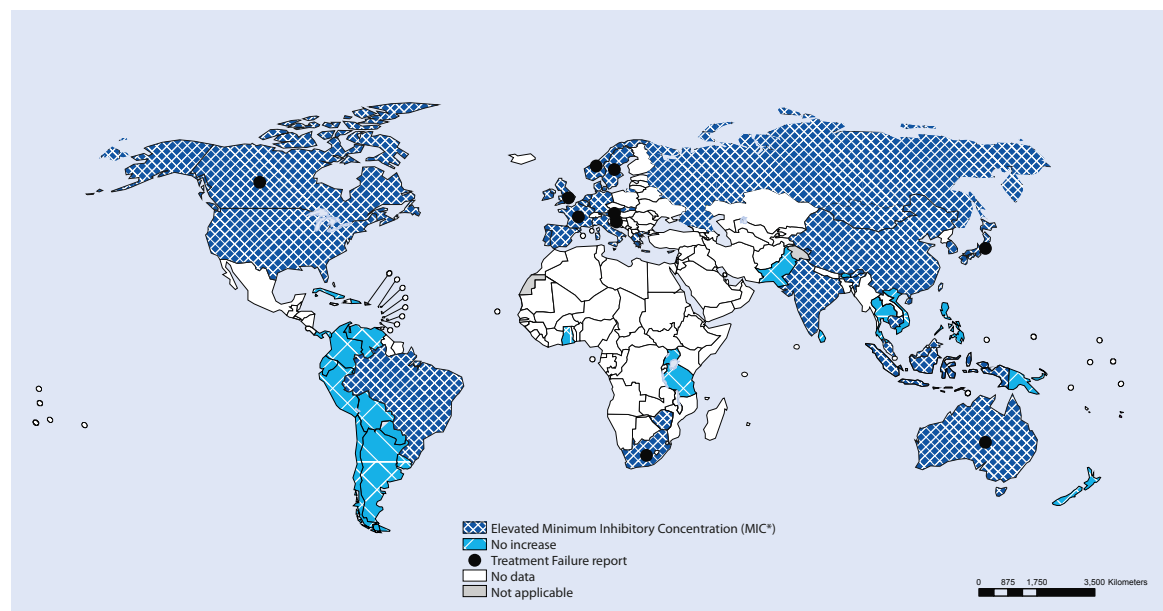
| Data sources based on at least 30 tested isolates                                                                                  | Overall reported range of proportion with decreased susceptibility (%) |
|------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| African Region<br>– National data and/or GASP data (n=2 countries)<br>– Publications (n=5) from 5 additional countries             | 0–12<br>0                                                              |
| Region of the Americas<br>– National data and/or GASP/ GISP data (n=4 countries)<br>– Publications from remaining countries (n=0)  | 0–31                                                                   |
| Eastern Mediterranean Region<br>– National data and/or GASP data (n=2 countries)<br>– Publications (n=1) from 1 additional country | 0–12<br>0                                                              |
| European Region<br>– National data and/or EURO-GASP/GRASP data (n=17)<br>– Publications (n=3) from 3 additional countries          | 0–36<br>0                                                              |
| South-East Asia Region<br>– National data and/or GASP data (n=5 countries)<br>– Publications from remaining countries (n=0)        | 0–5                                                                    |
| Western Pacific Region<br>– National data and/or GASP data (n=12 countries)<br>– Publications from remaining countries (n=0)       | 0–31                                                                   |

EURO, European; GASP, Gonococcal Antimicrobial Surveillance Programme; GISP, Gonococcal Isolate Surveillance Project; Gonococcal Resistance to Antimicrobials Surveillance Programme (GRASP) network.

a. Based on antibacterial susceptibility testing with ceftriaxone or cefixime.

In countries where quality assured gonococcal antimicrobial susceptibility surveillance is taking place, there are rising trends in decreased susceptibility and resistance in *N. gonorrhoeae* to cefixime and ceftriaxone. There are 36 countries that report decreased susceptibility to third-generation cephalosporins (21-24) (Figure 13).

**Figure 13** Detection of decreased susceptibility to third-generation cephalosporins in *Neisseria gonorrhoeae*<sup>a</sup> (20-23) and treatment failure (24-34) up to 2010



\* Note: cefixime >0.25µg/L or ceftriaxone >0.125µg/L. The definition of decreased susceptibility to third-generation cephalosporins differs across AMR testing methods. Countries are shaded where there has been any report of decreased susceptibility within their jurisdiction.

### Public health implications

Emerging resistance has created important barriers for the treatment and control of gonorrhoea, in both resource-constrained and higher income countries. Because of widespread resistance, older and cheaper antibacterial drugs are no longer of use in treatment regimens.

Treatment failures with a third-generation cephalosporin (cefixime) were first reported in Japan in 2007 (25), and during subsequent years verified treatment failures have also been reported in Australia, Canada, France, Norway, South Africa and the United Kingdom of Great Britain and Northern Ireland (UK) (26, 27, 31, 32, 34, 35). Furthermore, reports of treatment failure of pharyngeal gonorrhoea with ceftriaxone have been verified in Australia (29), Japan, Slovenia and Sweden (28, 30, 33, 36).

Most of the reports on treatment failure with third-generation cephalosporins are from developed countries, but most gonococcal disease occurs in less well-resourced countries and settings. Accordingly, the reports of treatment failures are under-reported because surveillance data on antibacterial susceptibility, and particularly treatment failures, from resource-constrained settings are scarce.

It is anticipated to be only a matter of time before gonococci with full resistance to the third-generation extended spectrum cephalosporins emerge and spread internationally. Consequently, gonorrhoea may become

untreatable unless new drugs become available. This is of global concern because there will be a major impact on disease control efforts due to increased prevalence of serious complications, and separate gonococcal entities such as neonatal infections and disseminated gonococcal infections will become much more common, as in the era before antibacterial treatment was available. In addition, untreated gonococcal infection is associated with an increased risk of acquisition and transmission of HIV infection.

Based on the 2008 global estimates of incident gonococcal infections, the estimate for global disability-adjusted life years (DALYs) generated by gonorrhoea is approximately 440 000. AMR in gonorrhoea will further increase this burden and cost for society, due to prolonged infections and greater numbers of patients with complications such as infertility, with potentially serious developmental implications. Financial costs for health services and individual patients will certainly increase due to the higher cost of treating resistant gonorrhoea (37).

To facilitate effective actions against the spread of multidrug-resistant *N. gonorrhoeae*, in 2012 WHO launched the *Global Action Plan to Control the Spread and Impact of Antimicrobial Resistance in Neisseria gonorrhoeae* (20). This action plan has to be implemented in the context of enhanced surveillance of sexually transmitted infection to facilitate early detection of emerging resistant strains, combined with a public health response to prevent and treat gonococcal

infections and mitigate the impact of cephalosporin-resistant *N. gonorrhoeae* on sexual and reproductive health morbidity.

### Key messages

- Data were obtained from only 42 of 194 (22%) of the Member States.
- The emergence of resistance to the last-resort drugs, the third-generation cephalosporins, is fast

outpacing the development of alternative treatment, and will influence disease burden with potential developmental impact.

- ABR surveillance is often lacking in countries with high disease rates. Thus, there is widespread absence of reliable resistance data for gonorrhoea where most needed, and consequently there is inadequate knowledge of the extent of the spread of resistant gonococci.

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SECTION  
**03**



# The health and economic burden due to antibacterial resistance

Whether antibiotic resistance poses a significant health and economic burden for patients and health-care systems is a key question (1). Previous studies to review the health and economic burden are limited (2-5). To address this knowledge gap, systematic reviews were carried out for this report, in order to systematically examine the current evidence relating to the health and economic burden of ABR in the following set of bacteria of major public health importance:

- *Escherichia coli*; resistance to third-generation cephalosporins and fluoroquinolones;
- *Klebsiella pneumoniae*; resistance to third-generation cephalosporins and carbapenems; and
- *Staphylococcus aureus*; resistance to methicillin (MRSA).

The burden due to each bacteria-antibacterial resistance combination was examined separately, based on the following questions:

- Are clinical outcomes different in patients who are treated for infections caused by bacteria with a specific resistance compared to those who are treated for infections without this resistance?
- Are economic outcomes and costs different for patients who are treated for infections caused by bacteria with a specific resistance compared to those who are treated for infections without this resistance?

## 3.1 Methods

A detailed description of the procedures is provided in Annex 3. The strategy for assembling and analysing the evidence from published studies (1946 to 26 March 2013) comprised three fundamental steps based on a predefined protocol with parameters of interest for the study questions:

1. A systematic review of the available published studies related to the study questions. Although the yield of articles from the literature search was high (>13 000 for each bacterium), only a limited number of publications addressed the questions adequately and were therefore included.
2. A meta-analysis to compare the patient health and health care-associated outcomes for infections caused by resistant and susceptible bacteria. All of the included studies reported at least one health or economic outcome of interest. Not all studies reported all outcomes, which is why the number of studies analysed varied by outcome considered.

3. Use of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for the grading of the quality of evidence into four categories: very low, low, moderate and high (6).

Ultimately, 25 studies met the inclusion criteria for third generation cephalosporin, and 12 for fluoroquinolone resistance in *E. coli*. Twenty-four studies were included for third-generation cephalosporin-resistant *K. pneumoniae*, and 13 for carbapenem-resistant *K. pneumoniae*. A total of 147 studies met the inclusion criteria for *S. aureus*. A full reference list with citations is provided in the detailed report in Annex 3. Among the included studies, all but nine (all of which were on *S. aureus*) were based on data collected during the 1990s and 2000s, and none included data before the 1970s.

## 3.2 Findings

All included studies on *E. coli* and *K. pneumoniae* were conducted in high- or upper-middle-income countries (Table 12) (7). Studies included for *S. aureus* were also

predominantly focused on populations in high- or upper-middle-income settings (95% of included studies).

**Table 12** Overview of studies included in the systematic review that addressed the health or economic impact of infections caused by the selected types of resistant bacteria

|                              | Antibacterial resistance                           | Studies included in SR (n) | Country income status <sup>a</sup> |                         |                         |                 |                                        |
|------------------------------|----------------------------------------------------|----------------------------|------------------------------------|-------------------------|-------------------------|-----------------|----------------------------------------|
|                              |                                                    |                            | Low income (n)                     | Lower-middle income (n) | Upper-middle income (n) | High income (n) | Mixed upper-middle and high income (n) |
| <i>Escherichia coli</i>      | 3 <sup>rd</sup> generation cephalosporin-resistant | 25                         | 0                                  | 0                       | 7                       | 17              | 1 <sup>a</sup>                         |
|                              | Fluoroquinolone-resistant                          | 12                         | 0                                  | 0                       | 0                       | 12              | 0                                      |
| <i>Klebsiella pneumoniae</i> | 3 <sup>rd</sup> generation cephalosporin-resistant | 24                         | 0                                  | 0                       | 13                      | 10              | 1                                      |
|                              | Carbapenem-resistant                               | 13                         | 0                                  | 0                       | 3                       | 10              | 0                                      |
| <i>Staphylococcus aureus</i> | Methicillin-resistant                              | 147                        | 0                                  | 2                       | 23                      | 117             | 5 <sup>b</sup>                         |

n, evaluated number of studies; SR, systematic review.

a. All countries included in the studies were high income except for one study that was in an upper-middle-income country.

b. One study of 75 different countries. In 2 studies, country of origin was unclear.

The GRADE tables summarizing the quality of the evidence concerning the health and economic burden for the investigated bacteria–antibacterial combinations (discussed below in Sections 3.2.1 and 3.2.2) are provided in Annex 3.

### 3.2.1 Health burden

The main findings on the difference in outcomes for infections caused by bacteria that were resistant or sensitive to the studied antibacterial drugs are summarized in Table 13. Detailed findings for the complete list of outcomes are provided in Annex 3, Table A3.2.

**Table 13** Overview of the findings addressing the question: Does the published scientific literature support that there is a difference in outcome for patients with infections caused by the selected bacteria if they are resistant or sensitive to the relevant specific antibacterial drugs?

|                                  | <i>Escherichia coli</i>                   |                  | <i>Klebsiella pneumoniae</i>              |                            | <i>Staphylococcus aureus</i> |
|----------------------------------|-------------------------------------------|------------------|-------------------------------------------|----------------------------|------------------------------|
| Antibacterial resistance         |                                           |                  |                                           |                            |                              |
|                                  | 3 <sup>rd</sup> generation cephalosporins | Fluoroquinolones | 3 <sup>rd</sup> generation cephalosporins | Carbapenems                | MRSA                         |
| Outcome parameter                |                                           |                  |                                           |                            |                              |
| Bacterium-attributable mortality | Yes (n=4)                                 | No (n=1)         | Yes (n=4)                                 | No (n=1)                   | Yes (n=46)                   |
| 30-day mortality                 | Yes (n=11)                                | Yes (n=5)        | Yes (n=7)                                 | Yes (n=3)                  | Yes (n=16)                   |
| Hospital LOS                     | No (n=3)                                  | No (n=3)         | No (n=9)                                  | Unclear (n=3) <sup>a</sup> | Yes (n=50)                   |
| Admission to ICU                 | No (n=1)                                  | Yes (n=1)        | Yes (n=3)                                 | ND                         | No (n=17)                    |
| Post-infection LOS               | No (n=3)                                  | ND               | Yes (n=4)                                 | No (n=1)                   | Yes (n=27)                   |

ICU, intensive care unit; LOS, length of stay; MRSA, methicillin-resistant *Staphylococcus aureus*; n, evaluated number of studies; ND, no data.

a. Data in two studies were inconsistent, and a third study could not be included in the analysis.

b. A small study found that there was not a significant increase in the risk of health-care facility transfer for patients with carbapenem-resistant *K. pneumoniae* infections; however, patients enrolled in this study may have come from long-term care facilities at the time of study enrolment, so this result may not be directly attributable to *K. pneumoniae*.

A sufficient number of publications were identified in the systematic review to provide an overall evaluation of the impact of resistance for several of the health outcomes of interest. A summary of the health outcomes identified in the systematic review are listed below, with the details provided in Annex 3.

For patients with third-generation cephalosporin-resistant (including ESBL) *E. coli* infections there was:

- a significant twofold increase in all-cause mortality, bacterium-attributable mortality and in 30-day mortality;
- no significant increase in length of stay (LOS), ICU admission (based on only one study) and post-infection LOS.

For patients with fluoroquinolone-resistant *E. coli* infections there was:

- a significant twofold increase in both all-cause mortality and 30-day mortality for patients with fluoroquinolone-resistant *E. coli* infections;
- no increase in bacterium-attributable mortality (based on only one study), and no significant increase in LOS (but results were inconsistent in the two studies contributing to this result); and
- a significant twofold risk increase in infection-attributable ICU admission (based on only one study), and a significant increase in septic shock (but the result was imprecise and based on only one study).

For patients with third-generation cephalosporin-resistant *K. pneumoniae* infections there was:

- a significant increase in all-cause mortality, bacterium-attributable mortality and 30-day mortality, and in the risk of ICU admission;
- no significant increase in total LOS (but the results, which all indicated an increase in LOS, were too inconsistent across studies to pool into a single estimate), and no relationship found with progression to septic shock; and
- an increase in post-infection LOS found in four studies (but results were too inconsistent to allow a single estimate).

For patients with carbapenem-resistant *K. pneumoniae* infections there was:

- a significant increase in both all-cause mortality and 30-day mortality;
- no significant increase in attributable mortality or ICU mortality (based only on one small study), or in LOS (but results from the two studies that contributed to this estimate were inconsistent);
- an increase in ICU LOS (but based on only one study and its significance could not be ascertained), but no significant increase in post-infection LOS (but based on only one small study);
- no significant increase in the risk of health-care facility transfer for patients (but based only on one

small study), but a significant increase in the risk of discharge for long-term care (but patients enrolled in this study may have come from long-term care facilities at the time of study enrolment, so this result may not be directly attributable to *K. pneumoniae*).

For patients with methicillin-resistant *S. aureus* infections there was:

- a significant increase in:
  - all-cause mortality, bacterium-attributable mortality and ICU mortality;
  - post-infection LOS and ICU LOS;
  - septic shock;
  - discharge to long-term care for MRSA compared to methicillin-susceptible *S. aureus* (MSSA), and more than twofold risk increase for discharge to long-term care for MRSA compared to MSSA;
- no significant increase in:
  - 30-day mortality (but results were inconsistent across the studies);
  - LOS (but results across studies were somewhat inconsistent);
  - admission to ICU (but data from the studies that contributed to this estimate were inconsistent);
  - attributable readmission in patients with MRSA when compared to those with MSSA; and
- no significant risk of requiring mechanical ventilation with MRSA (but data from the studies that contributed to this estimate were inconsistent).

### 3.2.2 Economic burden

Few economic evaluations, or studies collecting health-care resource use alongside the clinical study, or retrospective data collection studies, were identified in the published scientific literature for *E. coli*, and none for *K. pneumoniae*. Some studies located in the literature search reported resource-use outcomes and were selected for inclusion in the health burden review. Although some published studies have evaluated the economic burden of ABR, few presented data that were sufficiently specific to be included in this review (3, 5, 8, 9). These results are consistent with the conclusion that the cost impact of ABR to health services, patients and society has not been adequately measured.

The main findings on the possible excess costs for infections caused by bacteria resistant to selected antibacterial drugs are summarized in Table 14. Detailed findings on costs are provided in Annex 3, Table C2. The costs summarized in these tables are the costs provided in the studies that were included in the systematic review of the clinical outcomes.

**Table 14** Overview of the findings addressing the question: Does the published scientific literature indicate that there is an excess cost due to infections caused by the selected bacteria if they are resistant to the relevant specific antibacterials?

|                              | Antibacterial resistance                           | Studies included in SR (n) | Studies reporting cost data (n) | Excess cost (n=studies reporting costs) |                                    |                           |                                        |
|------------------------------|----------------------------------------------------|----------------------------|---------------------------------|-----------------------------------------|------------------------------------|---------------------------|----------------------------------------|
|                              |                                                    |                            |                                 | Hospitalization <sup>a</sup>            | Antibacterial therapy <sup>b</sup> | Medical care <sup>c</sup> | Additional cost variables <sup>d</sup> |
| <i>Escherichia coli</i>      | 3 <sup>rd</sup> generation cephalosporin-resistant | 25                         | 2                               | Yes (n=2)                               | Yes (n=1)                          | Yes (n=1)                 | Yes (n=1)                              |
|                              | Fluoroquinolone-resistant                          | 12                         | 0                               | –                                       | –                                  | –                         | –                                      |
| <i>Klebsiella pneumoniae</i> | 3 <sup>rd</sup> generation cephalosporin-resistant | 24                         | 0                               | –                                       | –                                  | –                         | –                                      |
|                              | Carbapenem-resistant                               | 13                         | 0                               | –                                       | –                                  | –                         | –                                      |
| <i>Staphylococcus aureus</i> | Methicillin-resistant                              | 147                        | 19                              | Yes (n=17)                              | Yes (n=6)                          | Yes (n=6)                 | Yes (n=9)                              |

**SR, systematic review.**

- Definitions vary by study, and were not consistently reported. Costs generally represent billing charges for all services provided between hospital admission and discharge, and may or may not include readmissions.
- Some studies reported actual cost of antimicrobial drugs dispensed, while others may have reported the total cost of pharmaceutical management, including medication, determination of drug levels, dispensing by pharmacist, monitoring and adverse event management, and nursing costs related to administration.
- Similar to hospitalization, and also not consistently reported. Numbers generally exclude costs related to hospital administration and focus more directly on costs related to direct medical treatment.
- Additional cost variables available include: costs specifically related to the type of infection reported, daily hospital or patient costs; costs before or after infection; costs for specific allied health care; costs broken down into very specific categories; costs related to inpatient or outpatient treatment; costs reported by a specific time period (vs. entire stay), or adjusted or modelled cost variables produced in a study.

All costs for infections caused by resistant strains were consistently greater than those for infections caused by susceptible strains, with few exceptions (in very specific categories where small numbers of patients were assessed).

Studies on health-care resource use for *E. coli* were generally limited to the capture of hospital LOS data in upper-middle or high-income countries and the proportion of patients requiring treatment in ICU. The LOS for patients with fluoroquinolone or cephalosporin resistance was similar to that for patients with non-resistant infections, although the proportion of patients requiring ICU admission was higher (numerically for third-generation cephalosporin resistance, and statistically significant for fluoroquinolone resistance), suggesting that the intensity of care needed while in hospital differs in patients with infections caused by resistant bacteria compared to those caused by sensitive bacteria. Further, two studies (10, 11) found that the proportion of patients experiencing septic shock was statistically greater in patients with fluoroquinolone-resistant infections, which would involve more health-care resources than are required to treat patients with fluoroquinolone-sensitive infections.

Studies on *K. pneumoniae* related to economic burden were also generally limited to the capture of hospital LOS in upper-middle or high-income countries, and the proportion of patients requiring ICU admission.

There were numerically longer LOS in hospital and ICUs for patients with resistant infections, although the differences did not reach statistical significance. The proportion of patients requiring ICU admission was not reported in any of the studies. In one study (12) a higher proportion of patients with resistant infections were transferred to long-term care facilities, and this difference was statistically significant. However, many of these patients originally came from a long-term care facility to the hospital, and this factor must be taken into account in assessing whether patients with resistant infections may require more health-care resources in hospital and following discharge.

Regarding any increased cost associated with resistant *E. coli* and *K. pneumoniae* infections, few studies reported data, and the studies that were identified during the search have been included in previous reviews (2, 3, 5). For example, it was reported in one study from the United Kingdom that the additional costs for urinary tract infections caused by resistant (six drugs tested, included cephalosporins and fluoroquinolones) *E. coli* managed in general practice was £3.62 (13), and in another study from Thailand that the hospitalization costs increased to a median US\$ 528 from US\$ 108, respectively, in patients with ESBL-producing *E. coli* infections (14). A study in the USA in which *Klebsiella spp* and *E. coli* were included among other Gram-negative bacteria, reported that “patients infected with resistant bacteria had a median total

hospital cost US\$ 38 121 higher than that for patients infected with susceptible bacteria (US\$ 144,414 and 106,293 respectively)" (15).

The clinical trials for MRSA captured a number of resource-use outcomes (LOS, rates of readmissions, need for mechanical ventilation and discharge to secondary-care facility). Based on these trials, there was a longer duration of both hospital (mean difference of 4.65 days) and ICU LOS (mean difference of 4.0 days) for patients with MRSA compared to those with MSSA. In addition, a higher proportion of patients with MRSA tended to be discharged from hospital to other care facilities (long-term care facility or other health-care facilities). The information on resource use while in hospital is limited; few trials collected these data and the number of patients was often small. Based on the data on LOS, and the fact that a higher proportion of patients with MRSA were discharged to secondary-care facilities, the findings suggest that MRSA cases tended to require higher levels of care and resource use for both acute treatment and possible longer term complications.

The results of the present review are generally consistent with those of a recent review of data in the USA (5), which had a similar focus but was broader in its data gathering by including, for example, societal costs and impact of control programmes. In reviewing LOS and mortality, and patient costs attributable to AMR in the USA, cost appears to have been judged against

uninfected controls, or against infected or susceptible controls, whereas this review considered only infected controls. Both reviews found that costs were generally higher and that cost estimates were dependent on many methodological factors including whether studies were done at single or multiple institutions; the type of comparison (resistant vs. susceptible, or resistant vs. no infection), different methods used to estimate or collect costs, single or multiple diseases, and whether preventive measures were included in the cost estimates (this review did not include preventive measures). Both reviews also found that there was a wide range in the cost amounts across the studies; that the studies were heavily reliant on hospital-based data, and limited to middle-high and high-income settings; and that, because costs of resistance are mainly measured in inpatients, the overall burden may be underestimated.

A recent study (3) published since this review came to similar conclusions, and emphasized the need for research to estimate the impact of widespread resistance for the health system overall, including on care of patients with chronic noncommunicable diseases, and the need to bring together the relevant expertise to address knowledge gaps and provide robust estimates. For the time being, the limited information available should nevertheless be used to inform the development of improved models that can be applied to the assessment of the economic impact of resistance on health systems and society.

### 3.3 Knowledge gaps

A challenge for the systematic reviews was the lack of economic studies comparing the resource use associated with resistant versus non-resistant pathogens, because most economic evaluations tend to focus on the assessment of interventions. Available economic studies in this area tended to consider the costs due to resistant pathogens without comparing to non-resistant pathogens, or reported costs without describing the associated resource use, which made it difficult to determine the general applicability of the results. Ideally, comparative studies that directly capture resource use, with study duration sufficient to capture any long-term effect on health-care resource use, are needed. Such studies would allow for a better assessment of the economic consequences associated with resistant pathogens.

The findings in this report confirm those published previously – that there is a paucity of definitive cost-evidence available to allow for a comprehensive study of the economic burden of AMR. This is especially true with regard to data to assess the global and regional impact of specific bacteria–antibacterial resistance combinations. Data are currently limited to hospital systems of upper-middle and high-income countries, and this further complicates the task of

attempting to estimate the burden in developing countries, where potentially the burden could be most detrimental.

For the purposes of modelling cost–effectiveness, a “minimum data set” has been proposed with the following categories: epidemiological or clinical factors relating to resistance; cost factors relating to resistance; pattern of antimicrobial usage; impact on AMR in humans from non-human consumption of antimicrobials; and information concerning the costs and effectiveness of the policy evaluated (9).

Based on the current findings, the following gaps need to be addressed:

- standardization and implementation of a minimum data set;
- evaluation of both clinical outcomes and resource use in high-quality studies;
- evaluation of health and economic burden in a broader array of settings – including low- and low-middle-income countries; and
- need for improved models to assess economic impact on health-care systems and society.

### 3.4 Key messages

- A systematic review of published studies supports the hypothesis that infection with strains of the chosen bacteria carrying the investigated resistance mechanisms is associated with worse clinical outcomes for the patients.
- A number of comparative studies are available for making a general determination of the health burden of the investigated resistance mechanisms in the chosen bacteria in high-income settings, but there is a paucity of data concerning the health burden in low- and low-middle-income countries.
- There is a lack of properly designed and conducted economic studies to compare the resource use associated with resistant versus non-resistant pathogens.

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A large circular graphic with a white center. The text "SECTION 04" is written in a bold, purple, sans-serif font in the center. The circle is composed of several concentric rings. The outermost ring is dark purple. Inside it is a light blue ring. The next ring inward is a medium purple ring. The innermost ring is a light purple ring. The rings are separated by thin white gaps. There are also some decorative elements: a small blue arc on the left, a small purple arc on the right, and a small purple arc at the bottom. Dashed lines extend from the top, bottom, left, and right of the circle.

# SECTION 04

# Surveillance of antimicrobial drug resistance in disease-specific programmes

## 4.1 Tuberculosis

Tuberculosis (TB) is caused by the bacterium *Mycobacterium tuberculosis*, which differs in several ways from the other bacteria considered in this report. Mycobacteria grow only slowly; consequently, culture in the laboratory, which is necessary to study resistance to anti-TB drugs, is difficult. Also, mycobacteria can survive inside the body's immune defence cells, which is one of the reasons for the long duration of TB treatment.

Despite the progress in prevention and treatment of TB in recent years, 8.7 million people developed TB in 2012, and 1.3 million died as a result of the disease.

Drug-resistant tuberculosis (DR-TB) threatens global TB control and is a major public health concern in several countries. In 2012, an estimated 450 000 cases of multidrug-resistant TB (MDR-TB)<sup>a</sup> emerged globally confidence interval, (CI: 300 000–600 000) which corresponds to around 3.6% of all new cases and 20.2% of all previously treated cases of TB (Table 15). Over 50% of the estimated MDR-TB cases emerging in the world in 2012 were in China, India and the Russian Federation. An estimated 170 000 deaths (CI: 100 000–240 000) were caused by MDR-TB globally in 2012, including patients with concomitant HIV infection.

**Table 15** Estimated proportions of multidrug-resistant cases among new and previously treated TB cases, 2012, by WHO region

| WHO region | New   |                          |      | Previously treated |                          |      |
|------------|-------|--------------------------|------|--------------------|--------------------------|------|
|            | % MDR | 95% confidence intervals |      | % MDR              | 95% confidence intervals |      |
| AFR        | 2.3   | 0.2                      | 4.4  | 10.7               | 4.4                      | 17   |
| AMR        | 2.2   | 1.4                      | 3.0  | 13.5               | 4.7                      | 22.3 |
| EMR        | 3.5   | 0.1                      | 11.3 | 32.5               | 11.5                     | 53.5 |
| EUR        | 15.7  | 9.5                      | 21.9 | 45.3               | 39.2                     | 51.5 |
| SEA        | 2.2   | 1.6                      | 2.8  | 16.1               | 11.1                     | 21   |
| WPR        | 4.7   | 3.3                      | 6.1  | 22.1               | 17.6                     | 26.5 |
| Global     | 3.6   | 2.1                      | 5.1  | 20.2               | 13.3                     | 27.2 |

AFR, African Region; AMR, Region of the Americas; EMR, Eastern Mediterranean Region; EUR, European Region; MDR, multidrug resistance; SEA, South-East Asia Region; WPR, Western Pacific Region.

<sup>a</sup> MDR-TB is defined as resistance to at least rifampicin and isoniazid, the two most powerful first-line anti-TB medicines.

### 4.1.1 Evolution of drug resistance in tuberculosis

The development of resistance to anti-TB drugs began shortly after the initial introduction of antibacterial drugs for the treatment of TB. Already, during the first randomized clinical trial (RCT) in the 1940s, resistance to streptomycin was detected in a large majority of patients treated with that drug. The spread of drug-resistant strains was soon recognized and, despite the introduction of combination drug regimens throughout the world many years ago, the presence

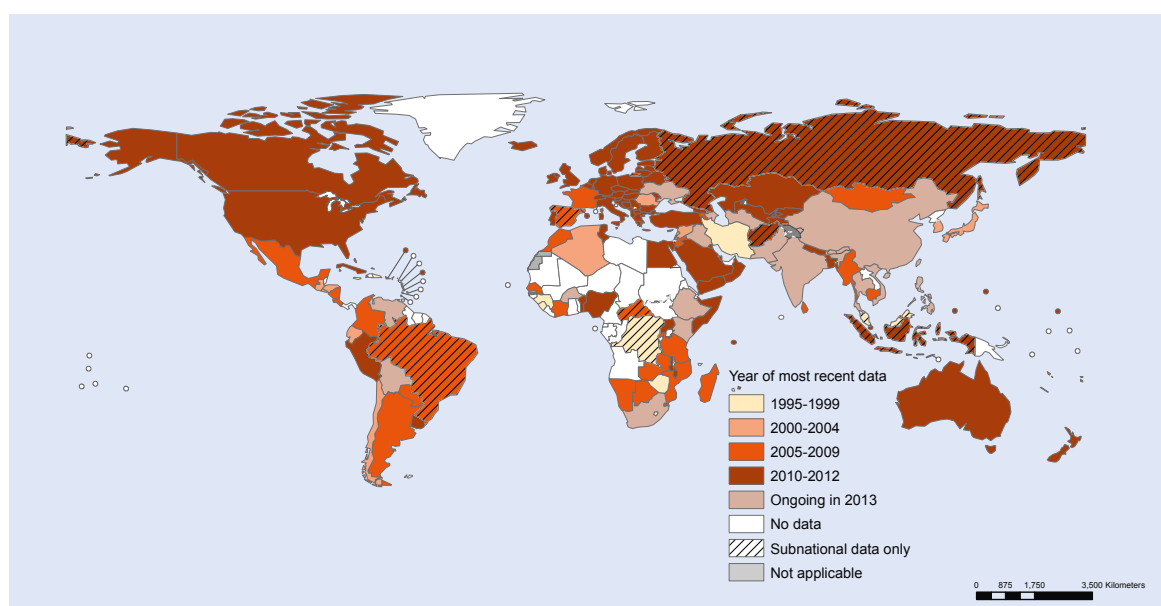
of drug resistance has been documented with increasing frequency from an ever wider geographic area. Drug-susceptible TB is treated for 6 months with a combination of four drugs – rifampicin, isoniazid, ethambutol and pyrazinamide. However, most treatment courses for MDR-TB last 20 months or longer, and require daily administration of drugs that are less effective and have more side-effects than those used to treat drug-susceptible forms of TB. Extensively drug-resistant TB is the most resistant variant.<sup>a</sup>

### 4.1.2 Surveillance of drug-resistant tuberculosis

#### Coverage of drug-resistance surveillance

Data on drug resistance have been systematically collected and analysed from 136 countries worldwide (70% of the WHO 194 Member States) since 1994, when the WHO Global Project on Anti-tuberculosis Drug Resistance Surveillance was launched. Of these countries, 71 have continuous surveillance systems based on routine diagnostic drug susceptibility testing (DST) of all TB patients, and 65 rely on special epidemiological surveys of representative samples of patients. The progress towards obtaining worldwide drug resistance data is shown in Figure 14.

**Figure 14** Progress in global coverage of surveillance data on anti-TB drug resistance, 1994–2012



Continuous surveillance based on routine DST of TB patients – with systematic collection, collation and analysis of data – is the most effective way to monitor trends in drug resistance over time. Additionally, surveillance systems can detect outbreaks that might otherwise go undetected, even if the original outbreak site had not been selected for inclusion in a survey. The number of countries that can rely on data generated by continuous surveillance systems is progressively increasing, due to the increasing

availability of laboratory facilities for culture and DST services.

Special surveys of a representative sample of notified TB cases are still the most common method of investigating the burden of drug resistance in settings where routine DST is not available for all TB patients due to lack of laboratory capacity or adequate resources (1). On average, every year national surveys are carried out in 20 countries worldwide, and 20 more are in preparation. Data generated by

<sup>a</sup> XDR-TB is defined as MDR-TB plus resistance to at least a fluoroquinolone and one second-line injectable agent (amikacin, kanamycin or capreomycin).

molecular technologies are now being incorporated into drug-resistance surveys, to simplify logistics and reduce laboratory workloads. In particular, in countries that do not yet have facilities for conventional culture and DST methods, or where laboratories cannot cope with the large workload generated by a survey, the new rapid test – Xpert® MTB/RIF – can play an important role. Xpert® MTB/RIF is an automated assay for the simultaneous detection of TB and rifampicin resistance directly from sputum in less than 2 hours. This method can be used to screen specimens for rifampicin resistance, and identify those requiring further testing at the NRL or supranational TB reference laboratory (SRL).

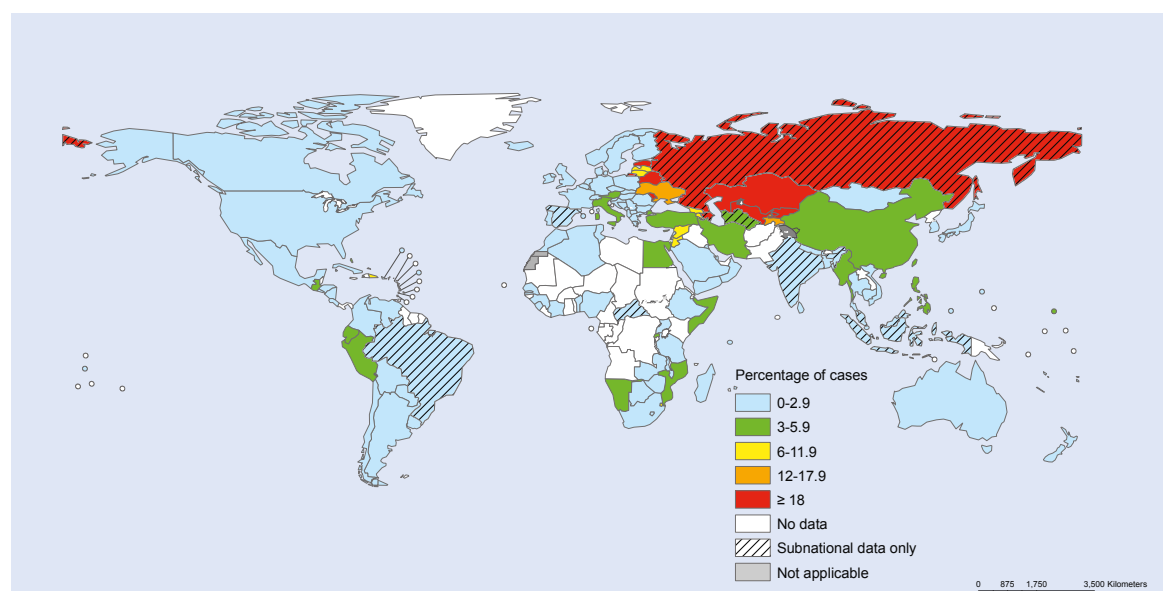
Drug-resistance surveys should be conducted regularly, approximately every five years, so that time trends in drug resistance can be monitored. Drug-resistance data are most lacking from central and francophone African countries, largely because of weakness of the laboratory infrastructure.

Anti-TB drug-resistance surveillance in countries is supported by an SRL Network, presently comprising 29 laboratories covering all six WHO regions.<sup>a</sup> The SRL Network is expanding its membership to include Centres of Excellence, a new category of laboratory specifically recognizing well-performing laboratories in large low- and middle-income countries that are also working specifically to build in-country laboratory capacity.

### Multidrug-resistant tuberculosis

The proportions of new TB cases with MDR-TB most recently reported by countries are shown in Figure 15.

**Figure 15** Proportion of new TB cases with multidrug resistance (MDR-TB) worldwide<sup>a</sup>



Numbers are based on the most recent year for which data have been reported, which varies among countries.

Proportions ranged from 0% to 34.8% and were highest in Azerbaijan (22.3% in 2007), Belarus (34.8% in 2012), Estonia (19.7% in 2012), Kazakhstan (22.9% in 2012), Kyrgyzstan (26.4% in 2012), the Republic of Moldova (23.7% in 2012), the Russian Federation (average: 23.1% in 2011) and Uzbekistan (23.2% in 2011). The proportion of previously treated TB cases with MDR-TB ranged from 0% to 68.6% for those countries reporting more than 10 previously treated cases in 2012.

Countries or subnational areas with the highest reported proportions of MDR-TB patients who had been previously treated were Azerbaijan (Baku city: 55.8% in 2007), Belarus (68.6% in 2012), Estonia (50.0% in 2012), Kazakhstan (55.0% in 2012), Kyrgyzstan (68.4% in 2012), the Republic of Moldova (62.3% in 2012), Tajikistan (56.0% in 2012) and Uzbekistan (62.0% in 2011). In the Russian Federation, although the national average proportion of cases with MDR-TB is less than 50% (average: 48.6% in 2011), it is well above 50% in several oblasts.

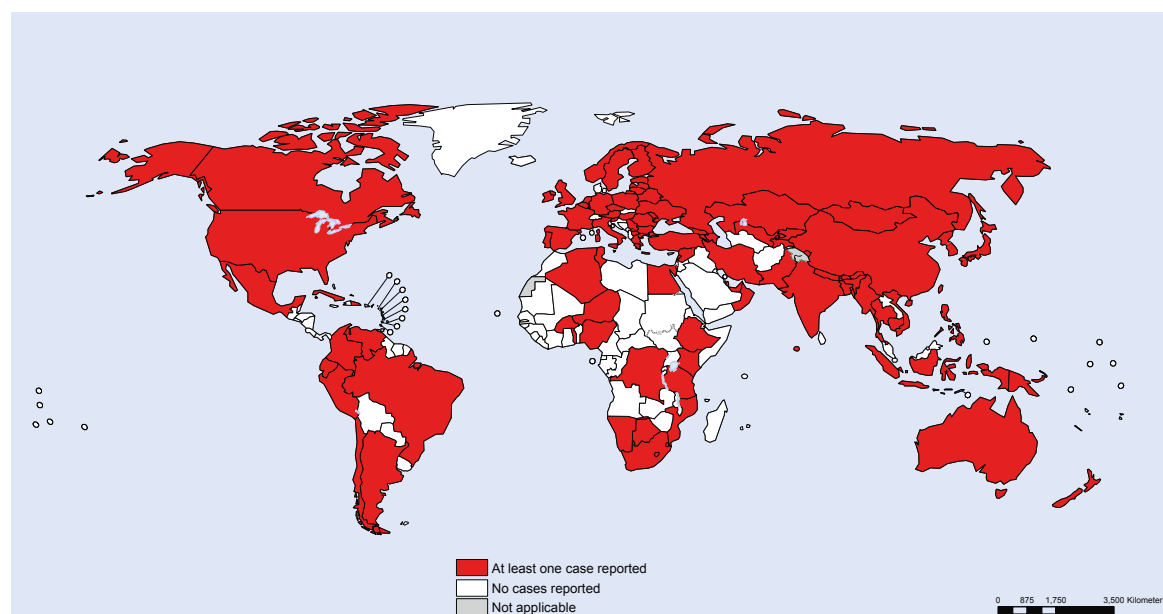
These data confirm that Eastern European and central Asian countries continue to be the regions with the highest levels of MDR-TB, with MDR-TB accounting for nearly one third of new TB cases and two thirds of previously treated TB cases in some settings.

<sup>a</sup> For the global SRL Network, see: [www.stoptb.org/wg/gli/srln.asp](http://www.stoptb.org/wg/gli/srln.asp)

## Extensively drug-resistant tuberculosis

Extensively drug-resistant TB (XDR-TB) had been reported by 92 countries by the end of 2012 (Figure 16).

**Figure 16** Countries that notified at least one case of extensively drug-resistant TB (XDR-TB) by the end of 2012



A total of 75 countries and 4 territories reported representative data from continuous surveillance or special surveys on the proportion of XDR-TB among MDR-TB cases. Combining their data, the proportion of MDR-TB cases with XDR-TB was 9.6% (95% CI: 8.1%–11%). Of these countries, 13 reported more than 10 XDR-TB cases. Proportions of MDR-TB cases with XDR-TB are highest in Azerbaijan (Baku city: 12.8%), Belarus (11.9%), Latvia (16.0%), Lithuania (24.8%) and Tajikistan (Dushanbe city and Rudaki district: 21.0%).

### 4.1.3 Global public health response to drug-resistant tuberculosis

#### Coverage of drug susceptibility testing

Targets included in the Global Plan to Stop TB 2011–2015 (2) stipulate that by 2015 all new cases of TB considered at high risk of MDR-TB (about 20% of all new confirmed cases), as well as all previously treated cases, should receive DST for at least the first-line drugs rifampicin and isoniazid, and that all patients with confirmed MDR-TB should also be tested for XDR-TB.

Globally, 5% of new bacteriologically confirmed TB cases and 9% of those previously treated were tested for MDR-TB in 2012. The proportions have increased slightly in recent years but remain below the target set for 2012 by the Global Plan. Among TB cases which were notified and confirmed as MDR-TB in 2012, 23% were reported to have had DST carried out for both fluoroquinolones and second-line injectable drugs, to test for XDR-TB. Much more widespread use of routine DST is urgently needed to improve the detection of MDR-TB and XDR-TB. Expansion of DST will require

strengthening of laboratory capacity, the introduction of new rapid diagnostics, and improved reporting from diagnostic centres. The increasing recognition of XDR-TB in the world (Figure 16) reflects the increased risk of acquisition of additional drug resistance or the increased transmissibility of resistant strains of TB when care and prevention are inadequate.

#### 4.1.4 Notification of MDR-TB cases and enrolment on treatment

The very limited use of DST in many countries is one of the main reasons why the number of patients with diagnosed MDR-TB remains low. In total, approximately 84 000 cases of MDR-TB were notified to WHO in 2012, with India, the Russian Federation and South Africa reporting more than a half of these cases. For 27 high burden countries, the estimated MDR-TB cases among notified pulmonary cases in 2012, notified cases of MDR-TB and enrolments on MDR-TB treatment in 2009–2012, and treatment outcomes reported for the cohort starting treatment in 2010 are shown in Table 16.

**Table 16** Recent estimated and notified MDR-TB cases, treatment enrolments and outcomes, in 27 high MDR-TB burden countries, by WHO region

|      | Estimated MDR-TB among notified pulmonary TB cases, 2012 |         | Notified cases |        |        |        |        |                                          | Cases enrolled on MDR-TB treatment |        |        |        | MDR-TB cases reported with treatment outcome data, 2010 cohort <sup>b,c</sup> |    |
|------|----------------------------------------------------------|---------|----------------|--------|--------|--------|--------|------------------------------------------|------------------------------------|--------|--------|--------|-------------------------------------------------------------------------------|----|
|      | Best estimate                                            | Range   |                |        |        |        |        |                                          |                                    |        |        |        | x                                                                             |    |
|      |                                                          | Low     | High           | 2009   | 2010   | 2011   | 2012   | 2012 notified/estimated (%) <sup>a</sup> | 2009                               | 2010   | 2011   | 2012   | N                                                                             | %  |
| AFR  | 38 000                                                   | 14 000  | 62 000         | 10 741 | 9340   | 12 384 | 18 129 | 48                                       | 5994                               | 7209   | 7467   | 9303   | 6166                                                                          | 66 |
| AMR  | 7100                                                     | 4500    | 9600           | 2884   | 2661   | 3474   | 2967   | 42                                       | 3153                               | 3249   | 3087   | 3102   | 2374                                                                          | 89 |
| EMR  | 18 000                                                   | 0       | 42 000         | 496    | 873    | 841    | 2236   | 12                                       | 707                                | 967    | 756    | 1602   | 676                                                                           | 77 |
| EUR  | 74 000                                                   | 60 000  | 88 000         | 28 157 | 33 776 | 34 199 | 36 708 | 51                                       | 17 169                             | 28 336 | 36 313 | 42 399 | 19 496                                                                        | 58 |
| SEAR | 90 000                                                   | 71 000  | 110 000        | 2560   | 3942   | 6615   | 19 202 | 21                                       | 2040                               | 3901   | 4597   | 15 845 | 3113                                                                          | 79 |
| WPR  | 74 000                                                   | 57 000  | 91 000         | 2059   | 4295   | 4394   | 4473   | 6                                        | 1429                               | 2210   | 4946   | 5070   | 2456                                                                          | 57 |
|      | 300 000                                                  | 220 000 | 380 000        | 46 897 | 54 887 | 61 907 | 83 715 | 28                                       | 30 492                             | 45 872 | 57 166 | 77 321 | 34 281                                                                        | 62 |

- a. Notified cases of MDR-TB in 2012 as a percentage of the estimated MDR-TB cases among all cases of pulmonary TB in the same year: the percentage may exceed 100% if estimates of the number of MDR-TB cases are too conservative and in the absence of linkage between the clinical and laboratory registers.
- b. The percentage of MDR-TB cases originally notified in 2010 with outcomes reported: the percentage may exceed 100% due to inclusion of updated information on MDR-TB cases in 2010, absence of linkage between notification systems for TB and MDR-TB, and the inclusion in the treatment cohort of cases of MDR-TB from a year prior to 2010.
- c. Treatment outcome reporting for 2010 cohort, in 27 high MDR-TB burden countries<sup>c</sup> and WHO regions. These countries account for about 85% of estimated MDR-TB cases globally, and are defined by overall number of cases or the level of MDR-TB among previously untreated cases.

The reported MDR-TB cases represent only about 21% of the estimated 450 000 (range 300 000–600 000) cases of MDR-TB likely to have emerged globally in 2012. Nonetheless, there has been an increase in the total number of MDR-TB cases detected and notified by countries between 2011 and 2012 in all WHO regions, except in the Region of the Americas. Although the total number of TB cases receiving second-line treatment for MDR-TB remains low compared with the Global Plan's targets, enrolment of MDR-TB patients worldwide increased by more than 150% between 2009 and 2012.

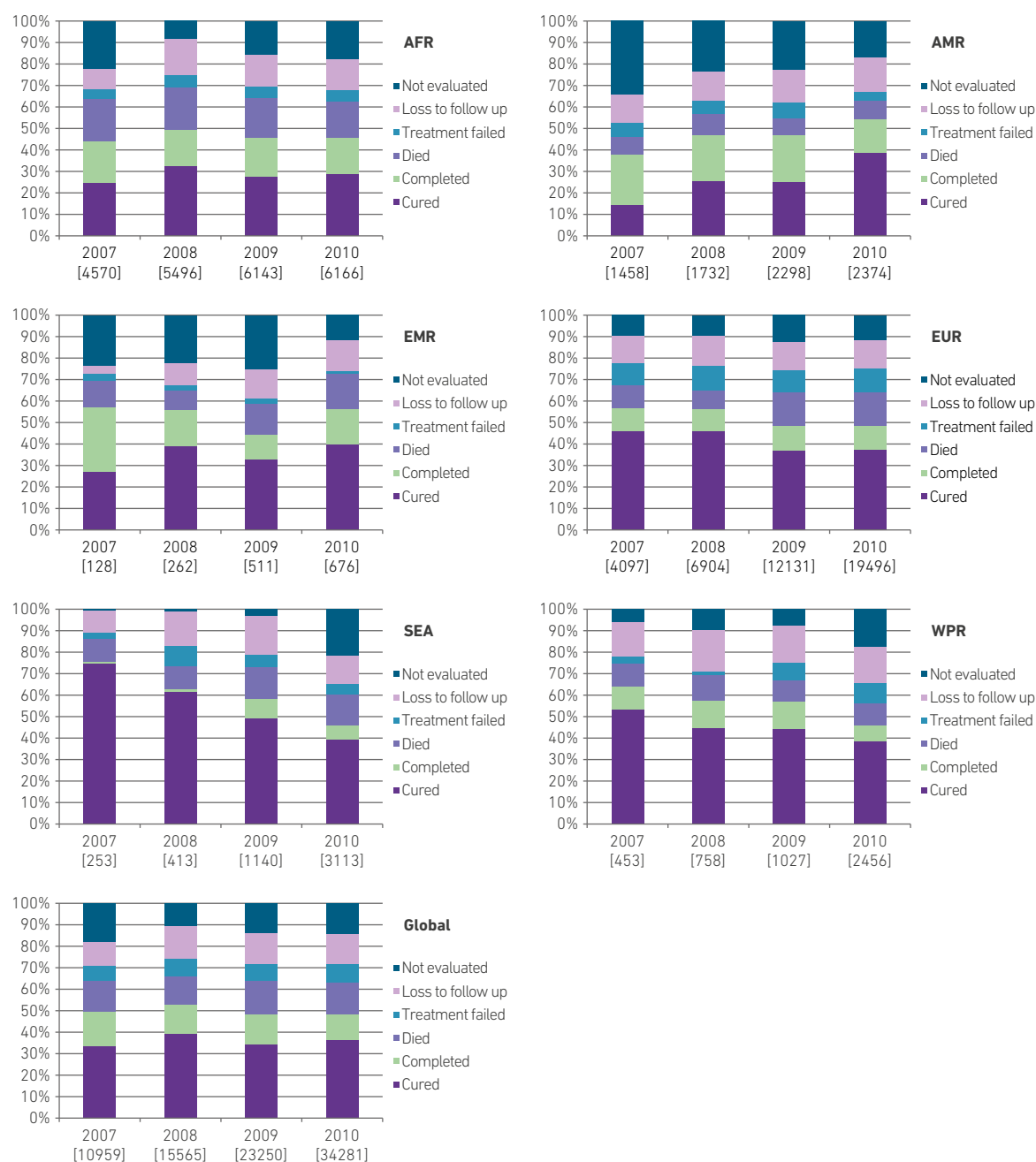
The proportion of MDR-TB patients starting second-line treatment in 2012 was 92% of all notified cases globally, but lower in the African (51%) and South-East Asian (83%) regions, reflecting a widespread shortfall in the capacity to provide treatment for diagnosed MDR-TB cases, particularly in those regions. Common constraints include the lack of trained staff, inadequate availability of second-line medication, insufficient treatment or monitoring facilities, incomplete reporting, and other weaknesses

in the coordinated functions required for effective programmatic management of DR-TB.

To reach the targets set out in the Global Plan and advance towards universal access to treatment, a strong concerted effort is still needed on many aspects of TB care, particularly in the countries where the burden is highest.

#### 4.1.5 Public health implications: treatment outcomes for multidrug-resistant and extensively drug-resistant tuberculosis

Standardized monitoring methods and indicators have enabled countries to report MDR-TB treatment outcomes in a comparable manner in recent years (3). The number of cases reported in annual MDR-TB treatment outcome cohorts tripled between 2007 and 2010, reflecting a steady increase in the extent of monitoring in all regions during this period (Figure 17).

**Figure 17 Treatment outcomes for patients diagnosed with MDR-TB, by WHO region, 2007–2010 cohorts**

The total number of cases with outcome data is shown below each bar following the year of start of treatment.

Overall, the proportion of MDR-TB patients in the 2010 cohort who were successfully treated was 48%, while 28% of these patients were reported as lost to follow-up or had no outcome information. Treatment success was highest in the Eastern Mediterranean Region (56%), as well as in the Region of the Americas (54%) where this proportion has increased steadily since 2007 together with a reduction in the proportion of cases that were not evaluated. In the 2010 cohort, mortality was highest in the African Region (17%) and the proportion of patients whose treatment failed was highest in the European Region (11%). Among a subset of 795 XDR-TB patients

in 26 countries, treatment success was 20% overall, with 44% deaths.

Further progress towards the global target for treatment success will require the scale-up of treatment programmes, enhancement of drug regimen effectiveness, supporting patients to encourage completion of treatment, and improved data collection and reporting. Positive recent developments include the introduction of short treatment regimens as WHO policy, and the introduction of bedaquiline for the treatment of MDR-TB in 2012, important steps towards better treatment outcomes for more TB patients.



### 4.1.6 Key messages

- Drug-resistant TB threatens global TB control and is a major public health concern in several countries.
- In 2012 it was estimated that, on a global level, 3.6% of new tuberculosis cases and 20.2% of previously treated cases had multidrug-resistant TB (MDR-TB). Frequencies of MDR-TB are much higher in Eastern Europe and central Asia than elsewhere in the world.
- There were an estimated 450 000 new MDR-TB cases in 2012, about half of which were in India, China and the Russian Federation.
- Extensively drug-resistant TB (XDR-TB) has been reported by 92 countries. The average proportion of MDR-TB cases which have XDR-TB is estimated to be 9.6%.
- There has been steady progress in the detection and treatment of MDR-TB since 2010. However, the approximate 84 000 cases of MDR-TB and 10 000 additional rifampicin-resistant TB cases notified to WHO globally in 2012 represented only 21% of the MDR-TB cases estimated to have emerged worldwide in that year.
- Of the MDR-TB patients who started treatment in 2010, only 48% (range 46%–56% in the WHO regions) were cured after completion of treatment. The treatment success rate was lower among XDR-TB cases.

## 4.2 Malaria

Malaria is caused by the protozoan parasite *Plasmodium* which is transmitted via the bite of female *Anopheles* mosquitoes. In the human body, parasites travel in the bloodstream to the liver, where they multiply and subsequently infect red blood cells. Among the five species of *Plasmodium* parasites that infect humans (*P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and *P. knowlesi*), *P. falciparum* and *P. vivax* are the most common. The most dangerous form of malaria, with the highest rates of complications and mortality, is caused by *P. falciparum*.

Early and effective treatment of malaria is a cornerstone of malaria control programmes. Malaria can quickly become life-threatening as the vital organs are deprived of oxygen and nutrients due to disruptions in the blood supply. WHO estimated that in 2010, 219 million cases of malaria occurred worldwide (CI 54 million to 289 million) and 660 000 people died from the disease (CI 490 000 to 836 000) (4).

### 4.2.1 Evolution of antimalarial drug resistance

There is no simple laboratory test to identify drug resistance in malaria. Instead, WHO defines antimalarial drug resistance as the ability of a parasite strain to survive and/or multiply despite administration and absorption of a drug given in doses equal to or higher than those usually recommended, but within tolerance of the patient (5). Cross-resistance can occur to drugs belonging to the same chemical family, or those that share the same modes of action.

Resistance develops in two phases. First, an initial genetic event produces a resistant parasite (de novo mutation). Such genetic events are spontaneous and

rare. In some instances, a single genetic event may be all that is required to confer drug resistance; in others, multiple independent events may be necessary before a resistant strain of the parasite emerges (6). In the second phase, resistant parasites are selected for and begin to multiply, eventually resulting in a parasite population that is no longer susceptible to treatment. Non-immune patients who are heavily infected and who receive inadequate amounts of an antimalarial drug are at high risk for de novo resistance. This can be prevented by provision of effective treatment and ensuring that patients follow exactly the prescribed drug regimens (7). The spread of resistance is further driven by the use of drugs which are eliminated only slowly from the body, such as chloroquine, mefloquine or piperaquine, thereby preventing infection by susceptible parasites but allowing infection by resistant parasites (8).

Resistance to antimalarial drugs has threatened global malaria control since the emergence of resistance to chloroquine in the 1970s. Studies have demonstrated that *P. falciparum* resistance to chloroquine and pyrimethamine both originated in South-East Asia and subsequently spread to Africa (9). Similarly, in the 1980s, resistance to mefloquine emerged rapidly on the western border of Cambodia and on the northwest border of Thailand only a few years after its introduction (10). In the 1990s, resistance of *P. falciparum* to amodiaquine and sulfadoxine-pyrimethamine was observed; these drugs are now among those used as partner drugs in artemisinin-based combination therapy (ACT).

#### 4.2.2 Surveillance of antimalarial therapeutic efficacy and resistance

*P. falciparum* resistance to artemisinin is suspected when  $\geq 10\%$  of patients who received treatment with an ACT have parasites detectable on the third day after the start of treatment. This resistance is confirmed when failure occurs after treatment with an oral artemisinin-based monotherapy with adequate concentration of the drug in the patient's blood, as evidenced by the persistence of parasites for 7 days, or the presence of parasites at day 3 and recrudescence within 28 or 42 days. Since 2006, when the first two cases of artemisinin resistance were confirmed in Cambodia, foci of either suspected or confirmed artemisinin resistance have been identified in Cambodia, Myanmar, Thailand and Viet Nam.

Antimalarial therapeutic efficacy can only be assessed by conducting clinical studies which estimate the failure rate following supervised administration of treatment, and which follow patients over a set follow-up period. For this purpose, and in response to the emergence of chloroquine resistance, WHO developed a standardized therapeutic efficacy study (TES) protocol. The protocol has evolved and been updated over time, most recently in 2009 (11). The WHO protocol provides study teams with standardized methods for making repeated

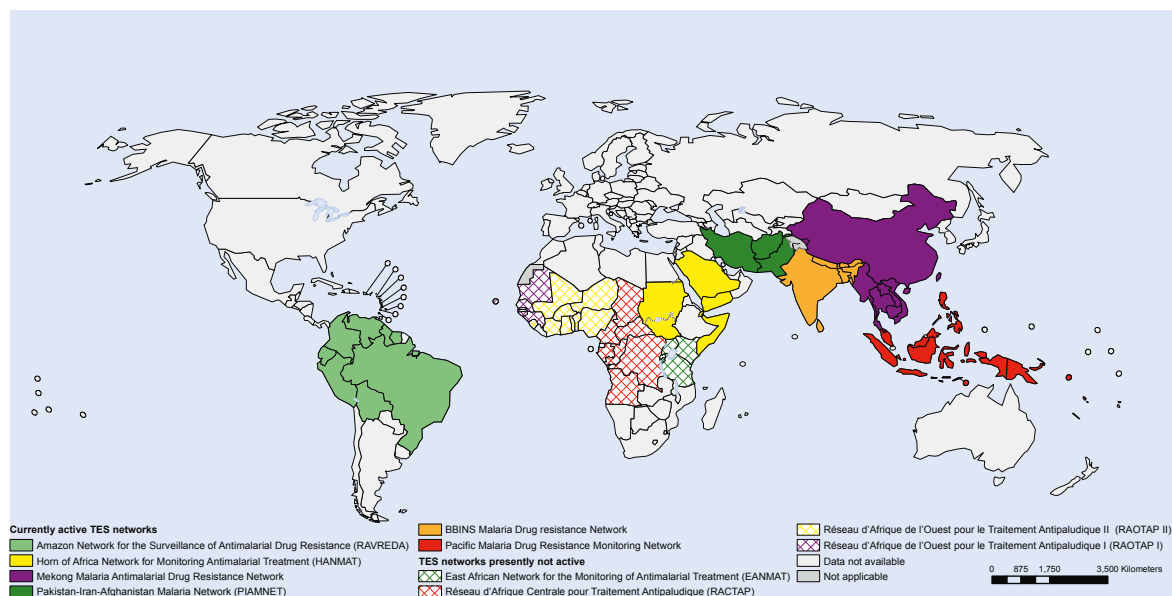
assessments of clinical and parasitological outcomes in patients who received supervised administration of treatment, over a follow-up of 28 or 42 days.

#### Therapeutic efficacy studies

Sentinel sites for TESs are selected based on population density, accessibility, and feasibility of supervision, malaria epidemiology, population mobility and migration; 4–8 sites generally provide adequate coverage of the variations in malaria transmission and prevalence that can occur within a given country. However, it is critical that the national malaria control programme (NMCP) has the capacity and resources to manage the studies: fewer studies of high quality are preferable to numerous studies of substandard quality. When a TES is conducted at the same sentinel site once every 24 months at the same time of the year, study findings provide a fundamental data source for the early detection of changes to antimalarial drug sensitivity, enabling timely changes to national treatment policy.

NMCPs are supported by regional networks for monitoring antimalarial drug resistance. Over the last 10 years, WHO has supported the creation of 10 networks, of which 6 are currently active (Figure 18).

**Figure 18** Regional and subregional therapeutic efficacy study networks for monitoring antimalarial drug efficacy



The networks help to strengthen national capacity for monitoring antimalarial drug efficacy. During the network meetings, held every year or every second year, NMCPs have the opportunity to present their most recent data, to share common challenges and collectively find solutions, plan subsequent studies, and discuss the status of antimalarial drug efficacy and treatment policies in areas close to common borders. Network meetings provide an important

venue for programme staff to stay informed about the evolving picture of antimalarial drug resistance in their region and globally. Stronger networks are likely to have played a role in increasing the number of countries conducting TES, from 31 countries in 2008–2009, to 47 in 2010–2011, and 49 countries in 2012–2013 (4). The results of TESs are published by WHO every five years (5).

An effective global surveillance system for drug efficacy involves support and coordination at the global, regional, subregional, and national levels. WHO regional offices support the NMCPs in maintaining continuity and momentum over time. WHO Headquarters provides regularly updated and simplified tools such as the WHO standardized protocol, and assists with protocol review, facilitating ethical clearance for studies, conducting clinical monitoring, procuring antimalarial drugs and providing financial support. An important factor in successful monitoring has been attribution of full credit and ownership of the studies to the NMCPs who are responsible for study design and implementation.

### 4.2.3 Global public health implications of antimalarial drug resistance

Antimalarial drug resistance is a major threat to malaria control, and has important implications for global public health. The emergence of chloroquine resistance in Africa in the 1980s was associated with increases in both hospital admissions and mortality at the community level (12, 13), increased risk of anaemia in pregnancy and low birth weight (14), and increased transmission (15).

Resistance to antimalarial drugs has had a significant impact on the cost of global malaria control, as new drugs have had to be developed to replace those that have become ineffective. In addition, patients whose treatment fails due to infection with a resistant strain require repeated consultations at health facilities for further diagnosis and treatment, resulting in lost work-days, absences from school, and increased health-care costs (16).

In the event that parasite sensitivity to artemisinin may become reduced, ACTs will continue to cure patients, provided the partner drug remains efficacious. In the short-term, the emergence of resistance to one component of the combination will not initially lead to

high mortality rates, as patients will still be protected by the partner drug. However, the emergence of resistance to artemisinin increases the risk that resistance to the partner drug will also develop. Without an effective alternative treatment, widespread resistance to both components of ACTs would be disastrous. To date, treatment failures following treatment with an ACT have only been observed in South-East Asia. Specifically, treatment failures occurred following administration of artesunate-mefloquine in Cambodia (17) and Thailand (18), and dihydroartemisinin-piperaquine in Cambodia (19). Without an alternative ACT, patients in western Cambodia now have to be treated with atovaquone-proguanil. However, this treatment is also vulnerable to resistance.

Because of the potential consequences if resistance to artemisinin were to become widespread, intensive efforts are under way to limit the emergence and spread of resistant parasites, notably in the Greater Mekong subregion (20, 21).

### 4.2.4 Key messages

- The estimated annual cost of containment operations in areas of artemisinin resistance is US\$ 10 – 20 per person at risk (21-22);
- Surveillance of antimalarial drug efficacy and resistance depends on clinical detection of treatment failures;
- An effective global surveillance system for antimalarial drug efficacy requires coordination at the global, regional, subregional, and national levels;
- Foci of either suspected or confirmed artemisinin resistance have been identified in Cambodia, Myanmar, Thailand and Viet Nam: further spread of resistant strains of malaria parasites, or the independent emergence of artemisinin resistance in other regions, could jeopardize all recent gains in malaria control and have major implications for public health.

## 4.3 HIV

Human immunodeficiency virus (HIV) infects cells of the immune system, destroying or impairing their function. If untreated, infection with the virus results in the progressive deterioration of the immune system, eventually leading to the development of acquired immunodeficiency syndrome (AIDS).

According to estimates by WHO and UNAIDS, 34 million people were living with HIV infection at the end of 2011. That same year, some 2.5 million people were newly infected, and 1.7 million (including 230 000 children) died of AIDS-related causes.

Antiretroviral therapy (ART) can slow progression of the disease by preventing the virus from replicating and

thus decreasing the amount of virus (i.e. the viral load) in an infected person's blood. HIV drug resistance refers to the ability of HIV to replicate in the presence of drugs that usually suppress its replication. Such resistance is caused by mutations in the genetic structure of the virus. Mutations are common in HIV because the virus replicates rapidly and does not contain the proteins needed to correct any mistakes made during this process. Therefore, some degree of HIV drug resistance is expected to occur, even when appropriate regimens are provided and adherence to treatment is optimal.

*Transmitted HIV drug resistance* refers to previously uninfected individuals being infected with drug-resistant virus, and *acquired HIV drug resistance* refers

to mutations being selected during viral replication in patients receiving ART. Pretreatment HIV drug resistance measures the level of resistance in patients at the start of ART; such resistance can be both transmitted and acquired, depending on whether there was exposure to antiretroviral (ARV) drugs before the start of ART. This might have happened unknowingly (as part of pre- or post-exposure prophylactic use of ARV drugs), during pregnancy (as part of efforts to curtail mother to child transmission of HIV) or as a result of unsuccessful attempts to start ART in the past.

#### 4.3.1 Surveillance of anti-HIV drug resistance

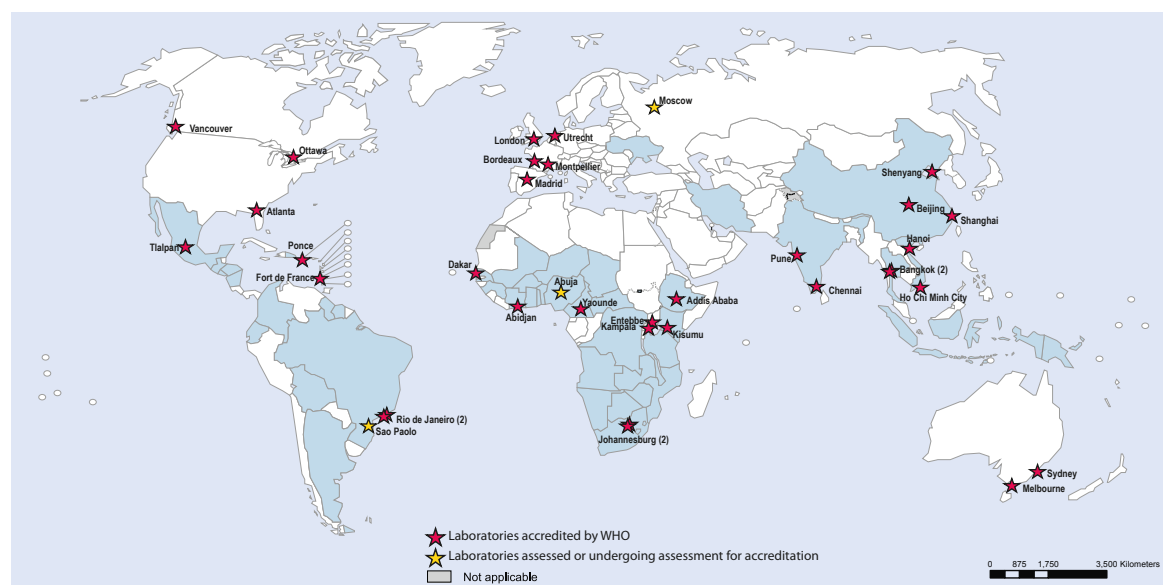
Understanding the emergence and transmission of HIV drug resistance at population level, and the interaction between its various determinants, requires routine monitoring of the performance of health services in delivering ART, and surveillance of HIV drug resistance in selected populations. The WHO Global HIV Drug

Resistance Surveillance and Monitoring Strategy includes the following elements (22):

- monitoring of early warning indicators of HIV drug resistance, which assess the performance of health services in delivering ART;
- surveillance of HIV drug resistance among:
  - adults initiating ART;
  - adults taking ART;
  - adults recently infected with HIV who are treatment naive; and
  - children under 18 months of age.

To ensure that high-quality assessment of HIV drug resistance is available to support country decision-making, WHO has developed a comprehensive HIV drug resistance laboratory strategy, and has accredited laboratories that implement rigorous quality assurance of genotyping data. As of 2012, WHO had accredited 29 testing laboratories for HIV drug resistance in 21 countries (Figure 19).

**Figure 19** Countries having implemented one or more elements of the WHO Global HIV Drug Resistance Surveillance and Monitoring Strategy (blue), and location of WHO-accredited genotyping laboratories for HIV drug resistance (as at end of 2012)



WHO and its collaborators in the HIVResNet have been monitoring the emergence of HIV drug resistance since 2004.

Data from 82 surveys found evidence of increasing levels of transmitted drug resistance to non-nucleoside reverse transcriptase inhibitors (NNRTIs) among recently infected and previously untreated patients. This was particularly the case in the areas surveyed in Africa, where the prevalence of NNRTI resistance reached 3.4% (CI: 1.8%–5.2%) in 2009. More widespread use of ART was associated with a higher prevalence

of NNRTI resistance, although this effect remained modest in most of the areas surveyed (23).

Among patients initiating ART, data from 36 WHO surveys in 12 low- and middle-income countries found that the overall prevalence of HIV drug resistance to any ARV drug ranged from 4.8% (CI: 3.8%–6.0%) in 2007 to 6.8% (CI: 4.8%–9.0%) in 2010.

In about 90% of patients still alive and on therapy at 12 months, the viral load was suppressed. Among those for whom viral load suppression was not achieved,

resistance was present in 72%, mostly to nucleoside reverse transcriptase inhibitors (NRTIs) and NNRTIs. In the remaining 28%, no resistance mutations were found; therefore, these patients experienced treatment failure for other reasons, such as poor adherence to treatment or extended interruptions of treatment, and may have been switched to costlier second-line regimens unnecessarily.

The resistance patterns among patients for whom first-line treatment failed after 12 months suggest that switching to standard second-line therapies (comprising two nucleoside class drugs and a boosted protease inhibitor) soon thereafter would be effective in suppressing the viral load in most cases.

Results from 50 countries monitoring early warning indicators for HIV drug resistance have found important gaps in service delivery and programme performance. This is particularly the case with respect to drug procurement and supply systems, adherence to treatment and the ability of treatment programmes to retain people in care.

### 4.3.2 Global public health implications of anti-HIV drug resistance

Evidence of HIV drug resistance before the start of treatment is strongly associated with treatment failure (i.e. virological confirmation that treatment has not suppressed the patient's viral load) (24, 25). Minimizing the emergence of drug resistance is therefore critical to maintain the long-term effectiveness of ART. Such therapy must be taken for life, and although the number of alternative drug combinations is increasing, it remains limited. In addition, the cost of alternative regimens is considerably greater than that of standard first-line combinations. Protecting the efficacy of the limited therapeutic options is essential for the sustainability of HIV programmes.

## 4.4 Influenza

Influenza imposes a global public health and economic burden for all populations, due to recurrent annual seasonal epidemics of acute respiratory illness caused by highly transmissible influenza A and B viruses. The threat of a pandemic event arises when a novel influenza A virus emerges to which humans have little or no immunity, and which has the potential to spread easily from person to person. Although annual epidemics result in about 250 000–500 000 deaths worldwide (26), pandemics may result in much higher mortality rates, as occurred in the 1918–1919 'Spanish Flu' pandemic, which resulted in as many as 50 million deaths (27).

Routine surveillance of HIV drug resistance has not kept pace with the scale-up of treatment in many countries, limiting the ability to reliably identify levels and patterns of HIV drug resistance and to assess trends over time. As ART continues to be rolled out, increased rates of drug resistance may occur. Hence, robust systems to assess levels of HIV drug resistance and monitor the factors associated with its emergence need to be in place to detect these patterns in a timely manner. National programmes are encouraged to carry out routine surveillance of HIV drug resistance in order to enhance programme planning and management, and to inform treatment policies.

### 4.3.3 Key messages

- HIV drug resistance causes ART failure. Therefore, minimizing the emergence of HIV drug resistance and its transmission is critical to ensure the continued effectiveness of ART, in view of the need for lifelong treatment, the limited treatment options available, and the fact that second-line and salvage treatment regimens are considerably more expensive, less patient-friendly and have more side-effects than WHO-recommended first-line regimens.
- With the expanded availability and use of ART, resistance to ARV drugs is slowly increasing.
- To limit the impact of HIV drug resistance on the effectiveness of ART, it is essential to ensure high-quality treatment and care services. The performance of treatment programmes can be monitored and improved using the early warning indicators for HIV drug resistance proposed by WHO. In addition, levels of HIV drug resistance should be monitored using WHO-recommended surveillance methods. Member States are encouraged to report their findings to WHO because they can play a critical role in the development of its ART guidelines.

### 4.4.1 Evolution of resistance in influenza viruses

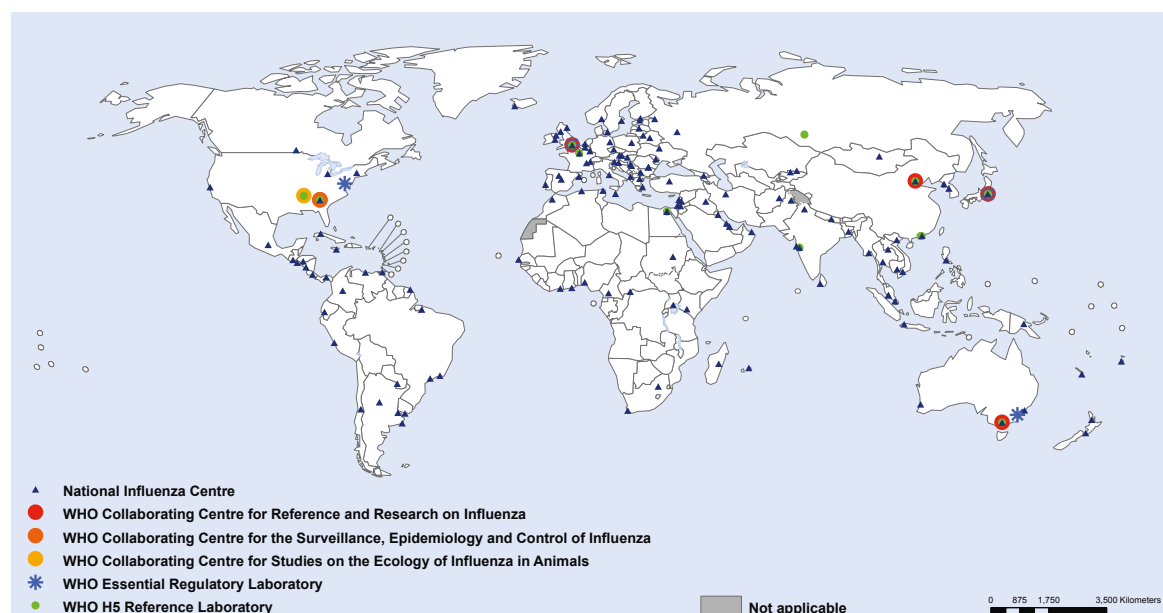
Influenza A viruses that affect humans may originate from a variety of animal hosts, but primarily birds and swine. They are subtyped according to the combination of their haemagglutinin (17 H subtypes) and neuraminidase (10 N subtypes) surface proteins. The A(H1N1) and A(H3N2) subtypes are currently in general circulation in human populations. These viruses evolve continuously, and the resultant new circulating viruses of the same subtype cause annual seasonal epidemics.



WHO has been continuously monitoring the evolution of influenza viruses for more than 60 years. The WHO Global Influenza Surveillance and Response System (GISRS), through its worldwide network (Figure 20) provides a solid scientific basis for global risk

assessment and recommendations in areas such as laboratory diagnostics, composition of influenza vaccines and antiviral drugs. In addition, GISRS provides a global alert mechanism for the emergence of influenza viruses with pandemic potential.

**Figure 20** WHO Global Influenza Surveillance and Response System



#### 4.4.2 Anti-influenza drug resistance

Although vaccines remain the primary tool for influenza prevention and control, over the past 10 years, antiviral drugs have been increasingly used for the treatment of epidemic and pandemic influenza. WHO has published guidance on their use in clinical management (28).

Currently, two classes of antiviral drugs are available for the treatment of influenza: adamantanes and neuraminidase inhibitors. However, due to widespread resistance to the adamantanes, these antiviral drugs are currently not recommended for use against circulating seasonal influenza A and influenza B viruses (26, 29). Adamantane resistance became fixed in A(H3N2) viruses after a rapid increase in prevalence during 2004–2005. For the 2009 pandemic influenza A(H1N1)pdm09 virus, the adamantane resistance M gene was acquired from its parental Eurasian swine virus.

The neuraminidase inhibitors oseltamivir and zanamivir, developed in the 1990s, are effective against both influenza A and B viruses, and are widely available. Oseltamivir has also been the principal choice for antiviral stockpiles, an important component of pandemic preparedness. The frequency of oseltamivir resistance in currently circulating A(H1N1)pdm09 viruses is low (1%–2%) (30). However, the emergence and rapid global spread in 2007–2008 of oseltamivir

resistance in the former seasonal A(H1N1) viruses has shown that viruses resistant to neuraminidase inhibitors could pose a serious threat to public health, and has raised the priority given to antiviral susceptibility surveillance in the WHO GISRS (31).

#### 4.4.3 Surveillance of anti-influenza drug resistance

Resistance and decreased susceptibility to anti-influenza drugs are detected by laboratory testing of virus isolates from patients with and without exposure to antiviral drugs. There are two sets of laboratory methods for the detection of resistance or decreased susceptibility: genotypic assays and phenotypic assays. The capacity in GISRS for antiviral susceptibility testing was developed only recently, mainly in countries where antiviral drugs are in use. Although all WHO regions currently have the capacity to carry out this testing, the laboratories use a wide range of protocols, and standards for interpreting and reporting test results are lacking.

Antiviral susceptibility testing is carried out by the GISRS WHO Collaborating Centres (WHO CCs) and some national influenza centres (NICs), providing broad baseline susceptibility data during each influenza season. However, NICs are in a position to generate more timely antiviral susceptibility data than the

WHO CCs, and this rapidity is critical for the early detection of resistant strains in the community and in clinical management.

The WHO Expert Working Group on Surveillance of Influenza Antiviral Susceptibility (AVWG) was formed in 2011 to develop practical approaches for GISRS NICs by advising on: appropriate surveillance strategy, laboratory methodologies, interpretation of laboratory surveillance data, classification criteria for reporting results, reference materials, quality and capacity-building. The AVWG also reviews the uptake of existing antiviral drugs, the status of development of new antiviral drugs, progress of new antiviral drugs through clinical trials into licensure and use, and current gaps in the methodologies of GISRS NICs to better incorporate these drugs for effective antiviral susceptibility surveillance (32).

#### 4.4.4 Public health implications of anti-influenza drug resistance

Influenza antivirals have several public health applications, including prevention of disease in exposed individuals at high risk for severe disease, therapy to reduce morbidity and mortality in patients with severe illness or at higher risk of developing severe disease, therapy among a broader population for disease mitigation, and reduction of secondary transmission. Specifically, influenza antiviral drugs, if taken properly, can reduce the risk of infection by 70% to 90% and duration of illness by 1–2 days; it can also reduce complications from secondary bacterial infections (28).

However, should anti-influenza drug resistance emerge undetected, the public health applications of influenza

antivirals could be undermined, increasing the threat of pandemics and severity of illness. For example, A(H5N1) influenza virus with high-level resistance to oseltamivir was discovered in two Vietnamese patients receiving treatment in January 2005 (33). Both patients died of the infection, despite early initiation (within 48 hours of the onset of symptoms) of high-dose treatment in one patient. Furthermore, antiviral drug resistance may complicate clinical treatment approaches in several ways, including limiting the options for combination therapy. Thus, during the 2005–2006 influenza season, the US CDC recommended against amantadine and rimantadine, because of widespread resistance among currently circulating seasonal A(H3N2) and A(H1N1) viruses (34).

#### 4.4.5 Key messages

- Influenza causes annual epidemics and periodic pandemics that have claimed millions of lives, imposing a major global public health and economic burden.
- Over the past 10 years, influenza antiviral drugs have become essential for treatment of epidemic and pandemic influenza infection; WHO has published guidance on the use of these drugs (29), and many countries have established stockpiles for pandemic preparedness.
- Widespread resistance to adamantanes currently circulating A(H1N1) and A(H3N2) viruses have left neuraminidase inhibitors as the primary antiviral agents recommended for influenza prevention and treatment, but resistance to these drugs is a growing concern.

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A large circular graphic with a white center. The text "SECTION 05" is centered in a bold, purple, sans-serif font. The circle is composed of several concentric rings. The outermost ring is dark purple. Inside it is a light blue ring. The next ring inward is a medium purple ring. The innermost ring is a light purple ring. The rings are separated by thin white gaps. There are also some decorative elements: a small blue arc on the left, a small purple arc on the right, and a small purple arc at the bottom. The background of the page is a light purple gradient.

# SECTION 05

# Surveillance of antimicrobial resistance in other areas

## 5.1 Antibacterial resistance in food-producing animals and the food chain

Resistance to antibacterial drugs has become a worldwide problem for both human and animal health, influenced by both human and non-human usage of antibiotics, and further enhanced by transmission through increasing international movement of people, animals and food.

The classes of antibiotics used in food-producing animals and in human drug are mostly the same (1), thereby increasing the risk of emergence and spread of resistant bacteria, including those capable of causing infections in both animals and humans (1-3). Food-producing animals are reservoirs of pathogens with the potential to transfer resistance to humans. The magnitude of such transmission from animal reservoirs to humans remains unknown, and will probably vary for different bacterial species. The spread of resistance genes from animal bacteria to human pathogens is another potential danger which adds complexity.

As well as their use in veterinary drug for treatment of animal diseases, antibacterial drugs are sometimes used in animal husbandry for disease prevention and (in half of the countries in the world) as growth promoters, involving mass administration (4). Herd treatment and antibiotic use in healthy food-producing animals constitute the main differences between the use of antibiotics in animals and in humans. In many countries, the total amount of antibiotics used in

animals (both food-producing and companion animals), measured as gross weight, exceeds the quantity used in the treatment of disease in humans (5, 6). The high populations and body mass of animals as compared to humans must be kept in mind in these comparisons.

The use of antibiotics in animal husbandry – including in livestock, poultry and fish farming – are leading to increasing recognition that urgent action is needed to avoid inappropriate use, and to reduce antibiotic usage in animal husbandry and aquaculture, as well as in humans. More data are needed on antibiotic consumption in food-producing animals worldwide, and on the occurrence of antimicrobial resistance in different countries and different production systems (4, 6), in order to make comparisons between countries and identify priority areas for intervention.

### 5.1.1 Ongoing surveillance of antimicrobial resistance in food-producing animals and food

Despite several international recommendations made during the last two decades, harmonized integrated surveillance of antimicrobial resistance in humans, food-producing animals and food is implemented in only a limited number of countries. Table 17 gives examples of some ongoing surveillance programmes, and the bacterial species included.

**Table 17** Examples of antimicrobial resistance surveillance and monitoring programmes

|                                          | Surveillance of resistant bacteria from |                  |      |                |                 | Bacterial species included |                      |                         |                    |                  |
|------------------------------------------|-----------------------------------------|------------------|------|----------------|-----------------|----------------------------|----------------------|-------------------------|--------------------|------------------|
|                                          | Healthy animals                         | Diseased animals | Food | Healthy humans | Diseased humans | <i>Salmonella</i>          | <i>Campylobacter</i> | <i>Escherichia coli</i> | <i>Enterococci</i> | Animal pathogens |
| <b>CIPARS (7) (Canada)</b>               | X                                       | X                |      |                | X               | X                          | X                    | X                       | X                  | X                |
| <b>Danmap (8) (Denmark)</b>              | X                                       | X                | X    | X              | X               | X                          | X                    | X                       | X                  | X                |
| <b>FINRES-VET (9) (Finland)</b>          | X                                       | X                | X    |                | X               | X                          | X                    | X                       | X                  | X                |
| <b>ONERBA (10) (France)</b>              | X                                       | X                | X    |                | X               | X                          | X                    | X                       | X                  | X                |
| <b>GERM-VET (Germany)</b>                |                                         | X                |      |                |                 | X                          |                      | X                       | X                  | X                |
| <b>JVARM (11) (Japan)</b>                |                                         |                  | X    |                |                 | X                          | X                    | X                       | X                  |                  |
| <b>NORM/ NORMVET (12) (Norway)</b>       | X                                       | X                | X    |                | X               | X                          | X                    | X                       | X                  | X                |
| <b>ITAVARM (Italy)</b>                   | X                                       | X                | X    |                | X               | X                          |                      | X                       | X                  | X                |
| <b>NETHMAP/ MARAN (13) (Netherlands)</b> | X                                       | X                |      |                | X               | X                          | X                    | X                       | X                  | X                |
| <b>NARMS (14) (United States)</b>        | X                                       |                  | X    |                | X               | X                          | X                    | X                       | X                  | X                |
| <b>SWEDRES/ SVARM (15) (Sweden)</b>      | X                                       | X                | X    |                | X               | X                          | X                    | X                       | X                  | X                |

Continuous surveillance programmes for antimicrobial resistance in food-producing animals and food that allow for at least partial comparison of data exist only in some EU countries, the USA and Canada.

A few supranational programmes have been established. This includes monitoring carried out by the European Food Safety Authority (EFSA), which each year produces a report on the occurrence, in most EU Member States, of resistance in the food chain and in foodborne pathogens in humans. Until recently, monitoring of resistance in food, animals and humans in the EU Member States was not coordinated. However, beginning with the first report in 2011, data on food and animals are now combined in a joint report with data from human infections (FWD-Net, see also Appendix 3) (16).

Differences in production systems, sampling methodology, sites and procedures, as well as differences in laboratory protocols/methodologies and prevailing bacteria, make comparison between countries difficult and in some instances impossible. Thus, there is a need to harmonize methodologies across surveillance systems to permit comparability,

to promote better regional and global coordination, and understanding of the problem. However, despite the differences, the limited set of data available provides some important information. The Global Foodborne Infections Network (GFN) is a capacity-building network that promotes integrated, laboratory-based surveillance and intersectoral collaboration among human health, veterinary and food-related disciplines. After initial training, some GFN sites have started to collect data that can be entered for surveillance purposes in a specific module of WHONET.

### 5.1.2 Integrated surveillance of antimicrobial resistance in foodborne bacteria

Integrated surveillance of antimicrobial resistance in foodborne bacteria is the coordinated sampling and testing of bacteria from food animals, foods, environmental sources and clinically ill humans, and the subsequent evaluation of AMR trends throughout the food production, processing and supply chain using harmonized methods.

WHO has recommended that countries develop antimicrobial surveillance programmes to integrate data from bacterial isolates originating from humans, food-producing animals, and retail meats (17–19). The World Organisation for Animal Health (OIE) has developed standards on this subject, which are published in the Terrestrial Animal Health Code (20) and the Aquatic Animal Health Code (21). The rationale of integrated surveillance is to detect the emergence and spread of resistant bacteria that may cause foodborne disease. The Codex Alimentarius *Guidelines for risk analysis of foodborne antimicrobial resistance* (22) also emphasize the importance of programmes for surveillance of the use of antimicrobial agents, and the prevalence of foodborne AMR as important sources of information needed for risk analysis. This type of surveillance monitors the emergence and spread of resistant bacteria in animal products and other foods destined for human consumption. To interpret the data fully, it is desirable also to integrate data on transmissible genetic material in zoonotic, commensal and pathogenic bacteria from humans, animals and food, as well as data on antibiotic consumption in human and animals, in a harmonized way. A major impediment to such harmonization is the lack of uniform standards and policies in sampling, testing and reporting. The extensive and increasing global trade in food animals and their derived commodities, and growing movement of people, highlight the growing importance of global data sharing on foodborne pathogens, diseases and AMR.

The WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance (WHO-AGISAR) was set up in 2008 to support WHO's effort to minimize the public health impact of AMR associated with the use of antimicrobial agents in all food-producing animals. In particular, the Advisory Group assists WHO on matters related to the integrated surveillance of AMR (collection and integration of antimicrobial use and AMR data along the producer-to-consumer continuum) and the containment of food-related antimicrobial resistance (23). AGISAR also re-examine and update the WHO list of Critically Important Antimicrobials. In recent years, WHO-AGISAR has collaborated with FAO to implement integrated foodborne pathogen and AMR surveillance in the poultry, beef, pig and aquaculture value chains in Asia and Africa. These collaborative efforts are intended to strengthen national capacities for AMR surveillance and to generate data and information to support the development of appropriate national policies, and the development of good animal husbandry, health and hygiene guidelines for value chain operators.

### 5.1.3 Antimicrobials of particular importance in human and veterinary medicine

The FAO/OIE/WHO Expert Workshops on Non-Human Antimicrobial Usage and Antimicrobial Resistance 2003 (Scientific Assessment) and 2004 (Management Options) recommended that the concept of “critically important” classes of antimicrobials for humans should be pursued by WHO. As a response to this request WHO developed in 2005 a list of Critically Important Antimicrobials for Human Medicine. The WHO list provides a ranking of antimicrobial drugs according to their importance in human drug to identify those antimicrobials whose effectiveness should be preserved to protect human health (24).

AMR also has an impact on animal health and may affect production costs. As is the case with humans, in some situations there are few alternatives for the treatment of infections in animals (25, 26). As an example, methicillin-resistant *Staphylococcus intermedius* has emerged as a significant animal health problem in veterinary drug (26). OIE has developed a list of antimicrobial agents of veterinary importance (27). The OIE list includes recommendations on restriction of the use in food-producing animals of antimicrobials that are critically important for both animal and human health. These currently include fluoroquinolones and third and fourth generation cephalosporins. Furthermore the OIE recommends that careful consideration be given to the potential use and authorization for use in animals of antimicrobials currently used only in humans to preserve their effectiveness.

### 5.1.4 Implications for human health from zoonotic transmission of resistant bacteria and genetic material

Foodborne diseases impose a significant burden on global human health (2). All-cause gastroenteritis is the second most common cause of morbidity and mortality in the world (28, 29). Diarrhoeal disease is the third leading cause of DALYs lost globally (30). Resistance to antimicrobial drugs in bacteria causing some of these infections increases severity of disease and results in poorer outcomes for patients (31, 32). Furthermore, the problem concerns not only foodborne infections, but also bacteria carrying different resistance mechanisms that can be transferred to humans. These bacteria can initially cause a silent carrier state and may later give rise to infections that are not recognized as being of foodborne origin. Examples are urinary tract or abdominal infections caused by *E. coli* that could have been transmitted via the food chain. There is also growing concern about transmission to human populations of MRSA related to high-density swine production (33).



### 5.1.5 WHO–FAO–OIE tripartite intersectoral collaboration on action

WHO, FAO and OIE have established a formal tripartite alliance to enhance global coordination and to promote intersectoral collaboration between the public health and animal health sectors as well as in food safety (under the “One Health” approach). The FAO/OIE/WHO Tripartite has identified AMR as one of the three priority topics for joint actions (34). Several initiatives illustrate the past and ongoing activities and commitment of the three organizations to jointly address AMR:

- Expert consultations in 2003, 2004, and 2006 followed by the development of the *Guidelines for risk analysis of foodborne AMR*, adopted by the Codex Alimentarius Commission in July 2011 (22). Since 2010, the OIE has undertaken to update all relevant standards on AMR including the *OIE list of antimicrobial agents of veterinary importance* (27);
- The World Health Day 2011 on Antimicrobial Resistance was organized by WHO with the participation of FAO and OIE;
- The OIE *Global Conference on the Prudent Use of Antimicrobial Agents for Animals*, held in March 2013, provided further guidance and recommendations, and called for international solidarity to fight against antimicrobial resistance everywhere;
- Implementation of collaborative projects on integrated surveillance of foodborne pathogens and AMR in food producing animal value chains;
- Tripartite collaboration on AMR advocacy and awareness raising, capacity building, development of appropriate national policies and promotion of prudent and responsible use of antimicrobial drugs,

including the adoption of good husbandry, health and hygiene practices as alternatives to using antimicrobial drugs.

### 5.1.6 Key messages

- Antimicrobial resistance has an impact on animal health, with potential adverse effects on food production.
- Microorganisms resistant to antimicrobials that emerge in animals may spread to human populations.
- There are gaps in monitoring antimicrobial usage in food animals and in analysis of its impact on emergence of AMR.
- There are gaps in understanding AMR transmission potential and mechanisms (by bacteria and resistance genes) through the food chain to humans and its impact on human populations.
- There is a lack of harmonized global standards for integrated surveillance of AMR in the food chain, and on monitoring of usage of antimicrobial drugs, which hampers both analysis and sharing of data. Sharing existing experiences of integrated surveillance could inform further development and implementation more broadly.
- The GFN experience has shown that there is a need for capacity-building and training in resource-limited countries, and that integrated surveillance is feasible using a step-wise approach.
- WHO is working closely with FAO and OIE to tackle the AMR issues at the animal-human interface through better coordination at global level and improved intersectoral and multi-disciplinary collaboration.

## 5.2 Antifungal drug resistance: the example of invasive Candidiasis

Fungi are a group of microorganisms characterized by growth as either budding yeasts or filamentous hyphae. Although fungi are ubiquitous, there is great variation in the geographical occurrence of different types of fungal infections. *Candidiasis* is a fungal infection caused by the yeast *Candida*, and is the most common cause of fungal infection worldwide (35–37). Invasive candidiasis is a major problem in patients receiving intensive antibacterial therapy, such as those in intensive care or receiving immunosuppressive therapy. Other examples of common fungal infections are aspergillosis, histoplasmosis and dermatophytosis (commonly known as ringworm).

*Candidiasis* ranges from superficial infections such as oral thrush to deeply invasive disease, such as the *Candida* bloodstream infection, candidaemia. Bloodstream infections are the most common form of invasive candidiasis. Prior antibiotic use is one of the common risk factors for *Candida* infection because it leads to alteration of the normal microflora. Over 20 species of *Candida* can cause infection. Response to antifungal therapy differs by *Candida* species. In some countries, recent data have demonstrated a marked shift in causative organisms of candidaemia towards species of *Candida* that have increased resistance to azoles such as fluconazole, the standard antifungal drug of choice in many countries, and to the recently introduced antifungals known as echinocandins.



### 5.2.1 Antifungal drug resistance in *Candida* species

Currently, there are only three classes of antifungal agents available to treat serious *Candida* infections: the azoles, the echinocandins and the polyenes (e.g. amphotericin B).

Azoles are used most frequently to treat *Candida* infections, but some *Candida* species are inherently less susceptible to the azoles, and some species develop resistance during prolonged therapy (37, 38). Echinocandins, when available, are the empiric treatment of choice. Formulations of amphotericin B are available in many countries, but this agent has higher toxicity than azoles and echinocandins. A few *Candida* species, such as *C. lusitanae*, can develop resistance during amphotericin B therapy. Although many azole-resistant *Candida* infections can be treated with drugs of a different class, significant cost, toxicity and absence of an oral formulation can present barriers to their use. In some developing countries only a single class of antifungal drug is available and, if resistance develops, there are no other treatment options. Given the limitations of available antifungal drugs, the following resistance profiles are of particular concern:

- resistance to azoles, especially fluconazole, because this is the standard (or only available) antifungal therapy in many countries;
- resistance to the newer class of antifungals, the echinocandins, which have replaced fluconazole as empiric therapy in developed countries; and
- multidrug-resistant bloodstream infections for which there may not be any available treatment options.

### 5.2.2 Antifungal drug resistance surveillance

Resources allocated for monitoring and reducing antifungal drug resistance are limited, and few countries carry out surveillance. There are significant gaps in information from most of Asia, Africa, the Middle East and parts of South America. Also, many of the existing data are limited to single-centre reports, which may bias results towards certain patient populations.

Antifungal susceptibility testing methods have changed over time, making trend comparisons difficult. Antifungal susceptibility testing is not performed in most resource-limited countries, and resistance in these settings is unknown. Little is known about developing resistance among the echinocandins.

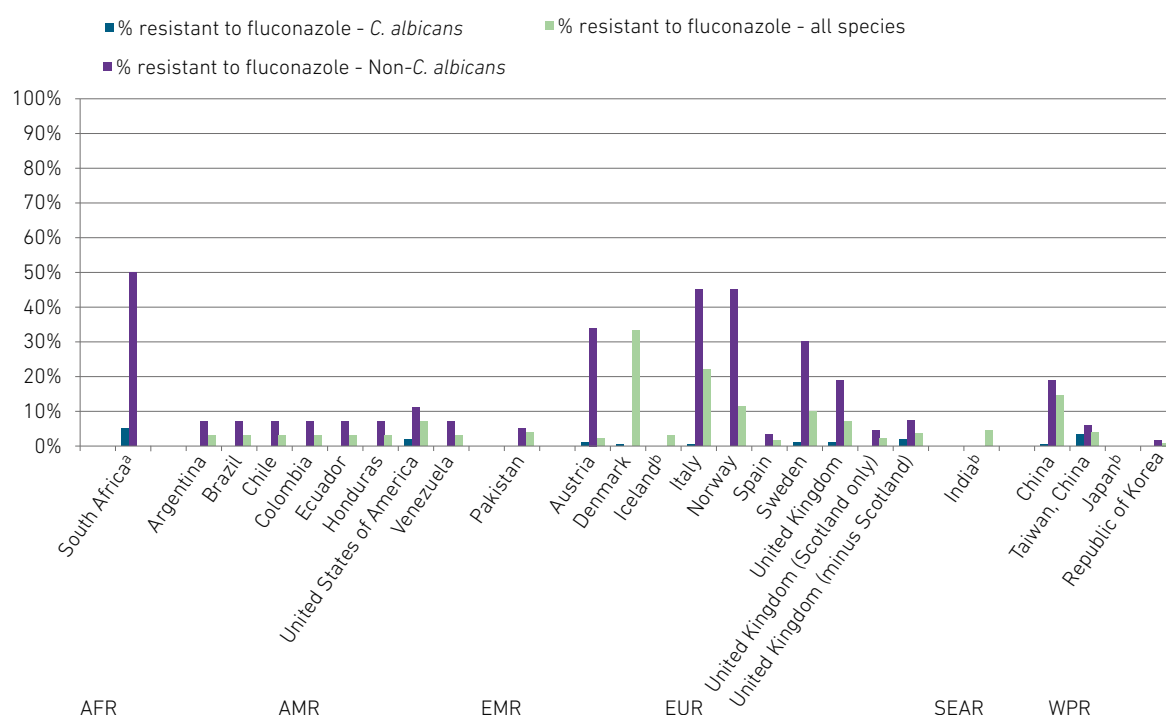
There are also only limited available data on how antifungal drug laboratory values correspond to how patients respond to the drug, especially among different populations. Moreover, the standard design of surveillance programmes is to collect the first isolate from each episode of infection, and generally before antifungal treatment. This method would not capture isolates that developed resistance after exposure to antifungal drugs. For these reasons, resistance might be greater than is currently being detected or reported.

More standardized data are needed to understand the full impact that resistant *Candida* species have on patient treatment and clinical outcomes.

### 5.2.3 Magnitude of resistance at a global level

Figure 21 shows resistance rates against fluconazole for *Candida albicans*, non-*C. albicans*, and all *Candida* isolates combined in selected countries from which data are available.

**Figure 21 Fluconazole drug resistance, by *Candida* species and country (12, 37, 39-45)**



AFR, African Region; AMR/PAHO, Region of the Americas/Pan American Health Organization; EMR, Eastern Mediterranean Region; EUR, European Region; SEAR, South-East Asia Region; WPR, Western Pacific Region.

- a. No data on overall resistance to fluconazole.  
b. No data on per cent resistant by species.

Data are compiled from prior published reports of candidaemia in hospitalized patients among state or national surveillance projects, and prospective laboratory surveillance projects. In most countries where data are available, drug resistance appears to be higher among non-*C. albicans* species than among *C. albicans* species. Resistance varies greatly by location and species, and overall reported resistance is highest in Denmark (33%) and lowest in the Republic of Korea (0.9%).

### 5.2.4 Public health importance

#### Health impact

In some locations, candidaemia is the most common cause of all bloodstream infections related to vascular catheters. Inappropriate antifungal therapy is associated with increased mortality, increased attributable costs, and increased burden of fluconazole non-susceptible *Candida* species (46).

#### Economic impact

Invasive *Candida* infections have been reported to be associated with high morbidity and mortality (mortality of approximately 35%), as well as higher health-care costs and prolonged length of hospitalization (46, 47). Patients with resistant infections may experience delay in receiving appropriate therapy, which can increase costs, LOS, and morbidity and mortality (48, 49). In 2005, CDC estimated that each case of *Candida* infection results in 3–13 days of additional hospitalization, and incurs a total of US\$ 6000 to US\$ 29 000 in direct health-care costs (46). Based on current data and projections, these infections add a total of US\$ 8 billion to US health-care expenditures every year (44, 46, 49, 50). Although it is suspected that resistant infections greatly increase these costs, few data exist on the economic impact of resistant *Candida* infections.

## Public health impact

*Candida* infections are a persistent and increasingly important public health problem, particularly for vulnerable populations such as cancer patients, transplant recipients, and in neonates and other patients in intensive care units. Geographic variability exists among patients with candidiasis in incidence, resistance, antifungal use and antifungal availability. In some locations, half of all infections are resistant to first-line therapy. Resistance to azoles is probably increasing, and resistance to the echinocandins is emerging. It is likely that the global burden will increase with increasing populations of immunocompromised patients as economies develop and health care improves. Given these changes, it is critically important to have active surveillance activities for resistance trends in *Candida* infections, to determine the burden of infections due to antifungal-resistant *Candida*, its economic impact, and possible areas where prevention and control strategies can be focused.

## 5.2.5 Key messages

- Candidiasis is the most common fungal infection worldwide, and invasive *Candida* infections have high morbidity and mortality rates.
- Antifungal drug resistance to candidiasis contributes to a burden for patients and the health-care system.
- Resistance to fluconazole, a common antifungal drug, varies widely by country and species.
- Resistance to the newest class of antifungal agents, the echinocandins, is emerging in some countries.
- There are large gaps in information on antifungal resistance and the global burden of antifungal-resistant *Candida*.

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SECTION  
**06**



# Conclusions

## 6.1 Main findings

### 6.1.1 Current status of resistance to antibacterial drugs

Whether plentiful or scarce, data on the resistance patterns for the bacteria of public health importance examined for this report were available in all WHO regions. National data obtained for *E. coli*, *K. pneumoniae* and *S. aureus* showed that the proportion resistant to commonly used specified antibacterial drugs exceeded 50% in many settings.

The reported and published data sets indicate that there are limitations in effective oral treatment options for some common community-acquired infections in several countries, and that there remain few, if any, treatment options for some common severe and health-care associated infections in many places. Of particular concern is the fact that *K. pneumoniae* resistant to carbapenems, usually the last line of available treatment, is reported in all WHO regions. Treatment failure due to resistance to available drugs is a reality in both gonorrhoea and TB.

However, with uncertainty about representativeness and considerable gaps in coverage, the magnitude of the problem at both population and global levels is unclear and needs to be clarified. It is also unclear to what extent differences in reported data for some bacteria–antibacterial drug combinations reflect real differences in resistance patterns, or are attributable to differences in sampling of patients, laboratory performance and methodology. Surveillance standards and international collaboration have been established for two types of bacterial infection – TB and gonorrhoea – but not for other common bacteria. To improve the quality and comparability of data, international collaboration based on standardized methodology is needed.

### 6.1.2 Burden of resistance to antibacterial drugs

The evidence obtained shows that ABR has a significant adverse impact on clinical outcomes and leads to higher costs due to consumption of health-care resources. However, the overall health and economic burden resulting from acquired ABR cannot be fully assessed with the presently available data; new methodologies are needed to more precisely assess the total impact of resistance, to better inform health policies and to prioritize the deployment of resources. The scarcity of

new classes of antibacterial drugs for Gram-negative bacteria adds additional urgency. It is essential to take appropriate measures to preserve the efficacy of the existing drugs so that common and life-threatening infections can be cured.

### 6.1.3 Surveillance of antibacterial resistance

#### Coordination and coverage

The data collected for this report reveal the lack of structures for coordination and information sharing that could provide an up-to-date overview of the present situation of ABR. Major gaps exist in national data from many countries. The most complete information was obtained from countries in the EU and the Americas, where long-standing regional surveillance and collaboration exist. Reports with a high proportion of limited data sets were obtained from countries in other regions, which may reflect other priorities or shortage of capacity in the health systems, or both.

Many of the submitted data sets were collected in 2011 or earlier. More recent data are needed at all levels to systematically monitor trends, to inform patient treatment guidelines and to inform and evaluate containment efforts. It is likely that patients in many places are treated for suspected bacterial infections in the absence of any information about the resistance situation in the local area.

There is no common coordinated widely agreed strategy or public health goal among identified surveillance efforts. The tables in Annex 2 illustrate the variety of sources for the data available for this report. There is agreement within EARS-Net and CAESAR (European Region) and ReLAVRA (Latin America) on the type of samples from which to compile data, but the methodology differs between these systems. WHO has provided standards and guidance for surveillance in several documents, as listed in Appendix 2. However, there is still no agreed methodology to be consistently implemented for global surveillance of ABR in common bacteria, and no agreed standard set of epidemiological information that should be collected to provide information on morbidity, mortality and costs for treatment and health-care systems.



### Limitations of available data

Most data compiled for this report present proportions of resistant bacteria among tested isolates of clinical samples compiled from routine testing at laboratories (i.e. laboratory-based routine surveillance), predominantly in hospital settings. This entails major pitfalls, such as lack of representativeness and ability to measure impact in the population.

When most samples come from patients with severe infections (particularly health-care associated infections and those for which first-line treatment failed), community-acquired and uncomplicated infections are underrepresented. This imbalance is likely to result in higher reported resistance rates than would be found for the same bacteria in community or population-based samples, as was shown in some reports with data submitted separately for these patient groups. In addition, lack of information on the source (patient) may lead to overrepresentation of a limited group of patients (e.g. patients with repeated hospitalizations or multiple sample collection, and outbreak settings), further biasing the results. Non-representativeness and biased sampling are major pitfalls for the interpretation and comparison of results. Treatment guided by limited and biased information may increase the risk of unnecessary use of broad-spectrum antibacterial drugs. This will increase the economic impact and accelerate the emergence of resistance to last-resort antibacterial drugs.

Laboratory-based routine surveillance can be valuable to inform treatment guidelines, and to provide information on trends and alerts to emerging ABR problems. However, this type of surveillance does not provide the information needed to measure the impact of ABR, including the consequences of ABR for patients as a result of failure of treatment that results in prolonged illness and excessive mortality, or how much of the population or which patient groups are affected, and so on. For this purpose, targeted surveillance based on defined populations and epidemiological samples would be necessary to provide the information needed to estimate ABR impact, as has been done in a few surveillance programmes and in the disease-specific programmes for TB, malaria and HIV. Lessons can be learnt from these programmes, and there may be opportunities for synergies from collaboration, although such solutions are not entirely transferable to surveillance of common bacteria. As exemplified by these other programmes, a long-term commitment, effort and considerable resources are needed to collect adequate data to determine the magnitude of the ABR

problem and guide interventions. Population-based surveillance of ABR would therefore be challenging, but is urgently needed to adequately guide policies and interventions.

### Timely information sharing

Surveillance systems need to be flexible and adaptable to emerging resistance, so that they are not restricted to monitoring what is already known. Surveillance systems should also be able to deliver information promptly to avoid any delay in public health actions at the local, national, regional and global level. WHONET, a widely used and freely available software supporting laboratory-based surveillance, can be useful for this purpose in stand-alone laboratories in resource-limited settings where commercial information technology systems are not accessible. WHONET also provides a platform for management and sharing of data. Increased collaboration between networks and surveillance centres will make it increasingly important to share experiences; shared experience will form the basis of coordinated collaboration on global surveillance of ABR.

#### 6.1.4 Surveillance and present status of antimicrobial drug resistance in disease-specific programmes

Resistance to antimicrobial drugs is a problem that has been addressed for many years by programmes dedicated to the control of TB and malaria, and more recently to the control of HIV and influenza. In these disease-specific programmes, unlike the situation for ABR, methodologically solid surveillance systems have been developed, with somewhat different approaches in each. The programmes are supported through broad stakeholder engagement, including by governments, public health institutes, reference laboratories and donor agencies. After years of sustained effort, the programmes have been able to deliver surveillance data to inform strategic planning and further actions. Despite some disease-specific considerations, there is scope for exploring potential opportunities for an integrated AMR surveillance approach, sharing lessons learnt, and collaborating to strengthen capacity for AMR surveillance. The emergence of AMR threatens the control of these diseases and is also a major public health concern.

### 6.1.5 Antibacterial resistance in food-producing animals and the food chain

There are major gaps in surveillance and sharing of data on resistant bacteria that are transmitted through the food chain. Surveillance in food-producing animals, as for surveillance in humans, is hampered by lack of harmonized global standards and platforms for data sharing. A multisectoral approach is needed to contain ABR in food-producing animals and the food chain. The tripartite collaboration between WHO, FAO and OIE, in the spirit of the 'One Health' approach, provides a coordinating platform for work in this area.

### 6.1.6 Resistance in systemic candidiasis

Although it is known in industrialized countries that antifungal resistance contributes a substantial burden to the health-care system, there are large gaps in knowledge of the global burden of antifungal-resistant *Candida*. The AST methods differ for fungi and bacteria; however, as diagnosis and treatment are frequently under the same health-care structures, there may be opportunities for collaborative efforts to strengthen surveillance capacities.

## 6.2 Gaps

The information compiled for this report on global AMR surveillance revealed the following main gaps:

- lack of coordinated global ABR surveillance – with a defined goal and agreed epidemiological and microbiological methods and standards – to provide a comprehensive situation analysis;
- a general lack of population-based ABR surveillance to provide information on the overall morbidity and mortality, and the economic burden and societal impact of ABR;
- gaps in methodology and integrated surveillance of resistance in human and foodborne pathogens; and
- lack of coordination among existing surveillance networks and surveillance centres to support opportunities for collaboration and data sharing.

## 6.3 The way forward

As this first WHO report on AMR surveillance shows, there is a need for an improved and coordinated global effort, including wider sharing of surveillance data, for public health actions, particularly for ABR. As outlined in the 2001 global strategy for containment of AMR (1), World Health Assembly resolution WHA58.27 and the 2011 World Health Day policy package (2), commitment is needed from Member States and partners. WHO can support and collaborate with Member States, existing surveillance networks, OIE and FAO and other relevant stakeholders to promote:

- development of tools and standards for harmonized surveillance of ABR and its consequences in humans, and continued support for integrated surveillance of ABR in food-producing animals and the food chain;
- collaboration between existing surveillance networks and surveillance centres towards coordinated regional and global surveillance;
- elaboration of strategies for population-based surveillance of AMR to provide more extensive information on health and economic impact.

## 6.4 References

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# Annex 1

## Methods for collecting data on surveillance and antibacterial resistance

The aim was to describe the status of surveillance and data on antibacterial resistance (ABR) in Member States. Data were sought from the following sources:

- national official sources, such as reports or other compilations at the national level at ministries of health, national reference laboratories, public health institutes or other sources identified by WHO;
- national and international networks for ABR surveillance; and
- scientific literature published from 2008.

Presentation of data in maps and tables:

- Because the focus of this report is to describe the status of national surveillance, priority was given to presentation of data collected from national official

sources, and information from other sources was not sought when the country information was based on a denominator of at least 30 tested isolates.

- In cases where data were not available from national official sources, available data included fewer than 30 tested isolates or collected data were incomplete, national surveillance networks or institutions were asked for additional information whenever possible.
- When data based on testing of at least 30 tested isolates were not available from the above sources, information was sought from publications (A1.3).

However, the tables in Annex 2 present all data obtained from national sources, surveillance networks or sites, and data that were received in parallel.

### A1.1 Definitions

- **Data set** is the data on a returned questionnaire or data on requested resistance proportions returned in any other compilation.

#### A1.1.1 Data sources

- **National data** refers to data returned on the questionnaire obtained from:
  - national official sources such as reports or other compilations at the national level from ministries of health, national reference laboratories, public health institutes or similar;
  - international official networks collecting national data, such as European Antimicrobial Resistance Surveillance Network (EARS-Net), Foodborne and Waterborne Diseases and Zoonoses Network (FWD-Net), Gonococcal Antimicrobial Surveillance Programme/Gonococcal Isolate Surveillance Project/Gonococcal Resistance to Antimicrobials Surveillance Programme (GASP/GISP/GRASP), Latin American Antimicrobial Resistance Surveillance Network (ReLAVRA) and Sistema de Redes de Vigilancia de los Agentes Responsables de Neumonías y Meningitis Bacterianas (SIREVA); and
  - other country sources identified by WHO.

This definition does not imply that the data collected are representative for that country as a whole, because information gaps are likely.

- **National data not available or incomplete** (either no data at all, or no data for a certain bacteria–antibacterial drug resistance) refers to the following situations:

- a response from the national official source that no national data are available on the questionnaire, via email or telephone contact, or from a WHO country situation analysis of antimicrobial resistance (AMR) activities; or
- the returned questionnaires from the national official source contain blanks; or state N/A (not applicable), NT (not tested) or 0 tested isolates for the requested bacteria–antibacterial drug resistance combinations.

- **National surveillance network/institution** refers to networks (a group of hospitals or laboratories) doing surveillance within a country, or institutions such as single hospitals, laboratories or similar that provide data directly or through national institutions.
- **Publication** refers to original studies published in peer-reviewed scientific publications.
- **Information obtained from Asian Network for Surveillance of Resistant Pathogens (ANSORP)** refers to the response to the surveillance network questionnaire (Appendix 1) obtained from the ANSORP coordinator.

- **Information obtained from RusNet** refers to the response to the surveillance network questionnaire (Appendix 1) obtained from the RusNet coordinator.
- **No information obtained for this report** refers to the fact that no information could be gathered for the purpose of this report during the project time.
- **Comprehensive surveillance** refers to surveillance based on inclusion of all bacterial isolates.
- **Targeted surveillance** refers to surveillance that includes only a subset of tested bacterial isolates (e.g. blood isolates or urinary isolates).
- **Type of population** (applies only to data extracted from literature review). The aim with the literature review was to see whether it could add any information on resistance rates where such information was not obtained from Member States. Whenever possible, a sense of the population studied is provided, to give some information on the variety of settings.
- **Samples** refers to anatomic site for sampling.

### A1.1.2 Type of surveillance, population or samples

- Whenever available, information on the type of surveillance, investigated population or samples was presented in the tables in Annex 2.

## A1.2 Data collection from Member States and networks

A standard questionnaire (Appendix 1) addressing existing national ABR reports or other types of national data compilations and recorded proportions of resistance in the selected set of nine bacteria–antibacterial resistance combinations was distributed to Member States.

The method for data collection varied somewhat by WHO region. To avoid duplication of work, resistance data already collected through the existing networks EARS-Net and FWD-Net were entered in the questionnaire by the European Centre for Disease Prevention and Control (ECDC). The questionnaires were then passed on for completion by the designated national AMR focal points, ministries of health, or public health institutes (as appropriate) in the participating countries. Some countries added data at this stage. Similarly, the WHO Regional Office for the Americas (AMRO) entered the information for the countries participating in ReLAVRA and SIREVA. In the other WHO regions, the questionnaires were distributed

by the WHO regional offices via country offices (as appropriate), usually to the ministry of health, a national reference laboratory or a public health institute.

The questionnaires were translated and distributed in English, French, Russian and Spanish, as considered appropriate by the WHO regional offices. In the WHO Regional Office for the Eastern Mediterranean (EMRO), the questions were transferred to a WHO web-based data entry interface (DataCol).

A similar protocol (Appendix 1) to that sent to Member States, with additional questions on methodological and technical points, was sent to a few national and international surveillance networks. The identification of networks was informed by the WHO technical consultation 2012 (7).

Data collection from Member States and international networks started in April 2013, and from national networks in June 2013. All information provided by the end of 2013 has been included in the report.

## A1.3 Literature search for data in scientific publications

The literature search for data was designed and carried out in collaboration with a medical information specialist, who assisted with selection of search terms for bacteria, resistance to listed antibacterial drugs, publications related to prevalence in humans and geographical location for study. Scientific journal articles on resistance rates in human isolates of the selected bacteria–antibacterial drug combinations published between 2008 and March 23 2013 were sought in the databases EMBASE and the WHO regional databases AIM (WHO Regional Office for Africa [AFRO]),

LILACS (AMRO), IMEMR (EMRO), IMSEAR (Regional Office for South-East Asia [SEARO]), WPRIM (WHO Regional Office for the Western Pacific Region [WPRO]).

The final yield (after removal of duplicates) was 6155 papers from EMBASE plus 411 from the regional databases, giving a total of 6566 papers, which were stored in two databases. These databases were searched as needed for the nine bacteria–antibacterial resistance combinations in cases where information on resistance–based on testing of at least 30 isolates had not been obtained from countries.

Studies with the following information were considered for inclusion:

- publications addressing resistance proportions based on defined patient populations, samples of individuals from the community or medical facilities (with or without symptoms), healthy carriers and populations subject to screening (e.g. health-care staff, day-care children), and, finally, results from antibacterial susceptibility testing (AST) on clinical samples collected in microbiology laboratories; and
- publications on proportions, prevalence or rates of ABR that included the name of any one of the requested bacteria (or “*enterobacteriaceae*” or “*Klebsiella*”); if resistance rates were not stated in the abstract, it was requested that it should be clearly indicated in the title or in the abstract that the paper included information on AST.

Published reports that were excluded were those that:

- did not fulfil the inclusion criteria;
- were posters, conference abstracts or similar;
- did not include original data, such as reviews, policy or position papers, treatment guidelines and similar;
- were based on a preselection (bias) of bacterial strains (e.g. outbreaks, case-reports, subspecies, serotypes and genotypes) or patient groups that had received prophylaxis with antibacterial drugs;
- evaluated interventions (e.g. infection control or antibacterial stewardship measures);
- focused on risk-factor analysis for carriage, infection or outcome after intervention;

- dealt specifically with enteric fever (*Salmonella enterica* serotypes Typhi and Paratyphi);
- focused on evaluation of microbiological or laboratory methods and pharmacodynamics;
- were related to evaluation (or marketing) of one specific antibacterial drug;
- reported clinical trials on treatment;
- were articles or abstracts from journals that could not be obtained from WHO library Internet services, if additional papers with sufficient information from the country in question was already available;
- did not report susceptibility (S), non-susceptibility (NS) or resistance (R) data from AST; and
- were based on fewer than 30 tested isolates, when larger series were available.

The retrieved abstracts were reviewed by one person. The minimal information considered necessary was the proportion of resistance, number of tested isolates, and information that either data collection or year of publication was 2008 or later. If any of this information was missing from the abstract, the full paper was evaluated.

Results on R, NS, and S were used as reported by the authors.

Data from the most recent time period were presented when:

- a single publication compared data over different time periods; and
- a single surveillance network published data for different years in different reports.

## A1.4 Reference

1. *Strategies for global surveillance of antimicrobial resistance: Report of a technical consultation* (WHO/HSE/PED/2013.10358), Geneva, World Health Organization, 2013. (<http://www.who.int/drugresistance/publications/surveillance-meeting2012/en/index.html>, accessed 6 January 2014).





# Annex 2

## Reported or published resistance rates in common bacterial pathogens, by WHO region

**Table A2.1 *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**African Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                   | Resistance (%)                            | No. tested isolates     | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------------------------|-------------------------------------------|-------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | National data from international publication (1) | 17                                        | 236                     | Invasive isolates                                        | (2003)–2005                | 2008                          |
| Angola                                              | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Benin                                               | National data                                    | 34                                        | 44                      | Invasive isolates                                        | 2012                       | 2013                          |
| Botswana                                            | National data                                    | 28.4                                      | 67                      | Invasive isolates                                        | 2012                       | 2013                          |
| Burkina Faso                                        | National data                                    | 36                                        | 220                     | Invasive isolates                                        | 2008–2009                  | 2013                          |
| Burundi                                             | National data                                    | 7.2                                       | 1645                    | Targeted                                                 | 2012                       | 2013                          |
| Cameroon                                            | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Cabo Verde                                          | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Central African Republic                            | National data                                    | 30                                        | 183                     | Comprehensive                                            | 2012                       | 2013                          |
| Chad                                                | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Congo                                               | National data                                    | 31                                        | 71                      | Invasive isolates                                        | 2012                       | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Democratic Republic of the Congo                    | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Ethiopia                                            | National data                                    | 53 (caz);<br>70 (cro)                     | 138 (caz);<br>154 (cro) | Comprehensive                                            | 2011–2012                  | 2013                          |
| Gabon                                               | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Gambia                                              | National data not available                      |                                           |                         |                                                          |                            | 2013                          |
| Ghana                                               | National data                                    | 23.5 (cro);<br>41 (ctx)                   | 88 (cro);<br>32 (ctx)   | Comprehensive                                            | 2013                       | 2008                          |
| Guinea                                              | National data                                    | 100                                       | 1                       | Comprehensive                                            | 2012                       | 2013                          |
| Guinea-Bissau                                       | National data                                    | 25 (ctx);<br>33.3 (cro)                   | 35                      | Comprehensive                                            | 2013                       | 2013                          |
| Kenya                                               | National data, incomplete                        | 60                                        |                         | Targeted                                                 | 2012                       | 2013                          |
| Kenya                                               | National network <sup>e</sup>                    | 20                                        | 15                      | Targeted                                                 | 2013                       | 2013                          |
| Kenya                                               | Publication (2)                                  | 87.2                                      | 109                     | Private hospital                                         | 2007–2009                  | 2012                          |
| Lesotho                                             | National data                                    | 2                                         | 107                     | Comprehensive                                            | 2012                       | 2013                          |
| Liberia                                             | National data not available                      |                                           |                         |                                                          |                            | 2010                          |
| Madagascar                                          | Publication (3)                                  | 18.2                                      | 88                      | Hospital isolates                                        | (2006)–2008 <sup>f</sup>   | 2010                          |
| Malawi                                              | National data                                    | 0                                         | 1                       | Comprehensive                                            | 2013                       |                               |
| Mali                                                | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Mauritania                                          | National data                                    | 10                                        | 10                      | Comprehensive                                            | 2013                       |                               |
| Mauritius                                           | National data                                    | 43.5                                      | 184                     | Hospital samples                                         | 2012                       | 2013                          |
| Mozambique                                          | No information obtained for this report          |                                           |                         |                                                          |                            |                               |
| Namibia                                             | National data                                    | 12                                        | 2345                    | Comprehensive                                            | 2012                       | 2013                          |
| Niger                                               | National data not available                      |                                           |                         |                                                          |                            | 2013                          |
| Nigeria                                             | Publication (4)                                  | 10                                        | 310                     | Blood isolates (children)                                | 2006–2008                  | 2010                          |
| Nigeria                                             | Publication (5)                                  | 20                                        | 80                      | Carriers                                                 | (2003)–2007                | 2008                          |
| Nigeria                                             | Publication (6)                                  | 37.5 (cro);<br>34.4 (caz);<br>28.1 (ctx); | 32                      | Clinical samples                                         | 2007                       | 2009                          |
| Nigeria                                             | Publication (7)                                  | 11.4                                      | 128                     | Hospital samples                                         | 2007                       | 2009                          |
| Nigeria                                             | Publication (8)                                  | 2.3                                       | 364                     | Hospital acquired urinary tract infections               | 2007–2008                  | 2009                          |
| Nigeria                                             | Publication (9)                                  | 0                                         | 31                      | Blood isolates                                           | 2004–2009                  | 2010                          |
| Nigeria                                             | Publication (10)                                 | 64.3                                      | 42                      | Urinary isolates                                         |                            | 2010                          |
| Nigeria                                             | Publication (11)                                 | 28.9 <sup>e</sup>                         | 66                      | Urine and stool samples (HIV/AIDS-patients)              | 2009–2010                  | 2011                          |
| Nigeria                                             | Publication (12)                                 | 3                                         | 32                      | Blood isolates (HIV-infected children)                   |                            | 2010                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                              | No. tested isolates                       | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|---------------------------------------------|-------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Rwanda                                              | Publication (13)                        | 38.3 (hospital patients); 5.9 (outpatients) | 94 (hospital patients); 102 (outpatients) | Urinary isolates                                         | 2009                       | 2011                          |
| Sao Tome and Principe                               | National data not available             |                                             |                                           |                                                          |                            | 2013                          |
| Senegal                                             | No information obtained for this report |                                             |                                           |                                                          |                            |                               |
| Seychelles                                          | No information obtained for this report |                                             |                                           |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                                             |                                           |                                                          |                            |                               |
| South Africa                                        | National data not available             |                                             |                                           |                                                          |                            | 2013                          |
| South Africa                                        | Publication (14)                        | 7                                           | 503                                       | Blood isolates                                           | 2007                       | 2008                          |
| South Africa                                        | Publication (15)                        | 7.6                                         | 473                                       | Intra-abdominal infections                               | (2004)–2009                | 2013                          |
| South Africa                                        | Publication (16)                        | 10.2                                        | 431                                       | Urinary isolates                                         | 2005–2006                  | 2009                          |
| South Sudan                                         | National data not available             |                                             |                                           |                                                          |                            |                               |
| Swaziland                                           | National data, incomplete               |                                             | 11                                        | Comprehensive                                            | 2013                       | 2013                          |
| Togo                                                | No information obtained for this report |                                             |                                           |                                                          |                            |                               |
| Uganda                                              | National data                           | 0                                           | 9                                         | Comprehensive                                            | 2012                       | 2013                          |
| United Republic of Tanzania                         | National data not available             |                                             |                                           |                                                          |                            | 2013                          |
| United Republic of Tanzania                         | Publication (17)                        | 4.7                                         | 64                                        | Children with diarrhoea                                  | 2004                       | 2011                          |
| Zambia                                              | National data                           | 37.4                                        | 107                                       | Targeted                                                 | 2012                       | 2013                          |
| Zimbabwe                                            | National data not available             |                                             |                                           |                                                          |                            | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data only on proportion producing ESBL (extended spectrum beta-lactamases).

**Table A2.2 *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>**  
Region of the Americas

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                    | Resistance (%)                         | No. tested isolates     | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|---------------------------------------------------|----------------------------------------|-------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Argentina                                           | National data                                     | 5.1                                    | 30 484                  | Uncomplicated urinary tract infection                    | 2010                       | 2012                          |
| Bahamas                                             | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Belize                                              | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data not available                       |                                        |                         |                                                          |                            | 2013                          |
| Brazil                                              | National data                                     | 0                                      | 247                     | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Canada                                              | National data                                     | 6.5 (caz);<br>9.4 (cro)                | 646                     | Sentinel hospitals                                       | 2011                       | 2013                          |
| Chile                                               | National data not available                       |                                        |                         |                                                          |                            | 2013                          |
| Chile                                               | National data from international publication (18) | 36.8 <sup>e</sup>                      | 76                      | Clinical isolates                                        | 2004–2007                  | 2008                          |
| Chile                                               | National data from international publication (19) | 23.8 <sup>e</sup>                      | 496                     | Hospitalized patients                                    | 2008–2010                  | 2012                          |
| Colombia                                            | National data not available                       |                                        |                         |                                                          |                            | 2013                          |
| Colombia                                            | Publication (20)                                  | 4.7(cro);<br>11.8 (ctx);<br>18.5 (caz) | 254                     | Urinary isolates                                         | (2005)–2008 <sup>f</sup>   | 2010                          |
| Colombia                                            | National data from international publication (18) | 20.2 <sup>e</sup>                      | 89                      | Clinical isolates                                        | 2004–2007                  | 2008                          |
| Costa Rica                                          | National data not available                       |                                        |                         |                                                          |                            | 2013                          |
| Cuba                                                | National data                                     | 42.9                                   | 179                     | Uncomplicated urinary tract infection                    | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Dominican Republic                                  | National data                                     | 33                                     | 2812                    | Hospital samples                                         | 2009                       | 2013                          |
| Ecuador                                             | National data                                     | 15.1                                   | 9259                    | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| El Salvador                                         | National data, incomplete                         |                                        | 486                     | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Guatemala                                           | National data                                     | 39.8                                   | 1607                    | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Honduras                                            | National data                                     | 36.7                                   | 3010                    | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Jamaica                                             | National data from international publication (18) | 8 <sup>e</sup>                         | 25                      | Clinical isolates                                        | 2004–2007                  | 2008                          |
| Mexico                                              | National data not available                       |                                        |                         |                                                          |                            | 2013                          |
| Mexico                                              | Publication (21)                                  | 55.7 (caz);<br>68.3 (cro)              | 165 (caz);<br>136 (cro) | Hospital laboratory                                      | 2004–2007                  | 2012                          |
| Mexico                                              | National data from international publication (19) | 48.4 <sup>e</sup>                      | 316                     | Hospitalized patients                                    | 2008–2010                  | 2012                          |
| Mexico                                              | National data from international publication (18) | 34 <sup>e</sup>                        | 238                     | Clinical isolates                                        | 2004–2007                  | 2008                          |
| Mexico                                              | Publication (22)                                  | 32.2 (caz);<br>41.7 (cro);             | 563                     | Clinical isolates (hospital)                             | 2005–2010                  | 2012                          |
| Nicaragua                                           | National data                                     | 48.1                                   | 271                     | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Panama                                              | National data                                     | 9.7                                    | 2318                    | Uncomplicated urinary tract infection                    | 2010                       | 2010                          |
| Panama                                              | National network                                  | 9                                      | 4321                    | Comprehensive                                            | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                                     | 1.4                                    | 1601                    | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Peru                                                | National data                                     | 24.8                                   | 1009                    | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Peru                                                | National network                                  | 50                                     | 3298                    | Comprehensive                                            | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report           |                                        |                         |                                                          |                            |                               |
| Trinidad and Tobago                                 | Publication (23)                                  | 9.4                                    | 716                     | Clinical isolates                                        | (2004)–2007                | 2008                          |
| United States of America                            | National data                                     | 14.6                                   | 9443                    | Health care associated infections                        | 2009–2010                  |                               |
| Uruguay                                             | National data not available                       |                                        |                         |                                                          |                            | 2013                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup> | Resistance (%)         | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------|------------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Uruguay                                             | Publication (24)               | 0                      | 253                 | Urinary isolates                                         | 2007–2008                  | 2010                          |
| Venezuela (Bolivarian Republic of)                  | National data                  | 12.5                   | 4114                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| International                                       | Publication (25)               | 26.8                   | 504                 | Intra-abdominal infections                               | 2008                       | 2011                          |
| International                                       | Publication (19)               | 9 (caz);<br>23.9 (cro) | 1517                | Hospitalized patients                                    | 2008–2010                  | 2012                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data only on proportion producing ESBL (extended spectrum beta-lactamases).

f. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

**Table A2.3 *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**Eastern Mediterranean Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                         | Resistance (%)                                | No. tested isolates                 | Type of surveillance, population or samples <sup>c</sup>           | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------------------------------|-----------------------------------------------|-------------------------------------|--------------------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report                |                                               |                                     |                                                                    |                            |                               |
| Bahrain                                             | National data                                          | 55                                            | 3795                                |                                                                    | 2012                       | 2013                          |
| Djibouti                                            | No information obtained for this report                |                                               |                                     |                                                                    |                            |                               |
| Egypt                                               | National data not available                            |                                               |                                     |                                                                    |                            | 2013                          |
| Egypt                                               | National surveillance (Hospital network <sup>e</sup> ) | 38.7 (caz);<br>50.1 (cro)                     | 315                                 | Hospital samples                                                   | (2002)–2010 <sup>f</sup>   | 2013                          |
| Iran (Islamic Republic of)                          | National data                                          | 41                                            | 885                                 | Invasive isolates                                                  | 2012                       | 2013                          |
| Iraq                                                | Publication (26)                                       | 9.6                                           | 73                                  | Hospital samples                                                   | 2005                       | 2013                          |
| Iraq                                                | Publication (27)                                       | 32.7                                          | 49                                  | Urinary isolates (outpatients)                                     |                            | 2012                          |
| Jordan                                              | National data not available                            |                                               |                                     |                                                                    |                            | 2013                          |
| Jordan                                              | Publication (28)                                       | 22.5 (caz)                                    | 113                                 | Urinary isolates (children)                                        | 2008                       | 2011                          |
| Jordan                                              | National data from international publication (1)       | 31                                            | 84                                  | Invasive isolates                                                  | (2003)–2005                | 2008                          |
| Kuwait                                              | Publication (29)                                       | 28                                            | 54                                  | Invasive isolates (children)                                       | 2005–2009                  | 2012                          |
| Kuwait                                              | Publication (30)                                       | 17 (community);<br>27 (hospital) <sup>g</sup> | 1745 (community);<br>770 (hospital) | Urinary tract infections: Community acquired and hospital acquired | 2005–2007                  | 2010                          |
| Lebanon                                             | National data not available                            |                                               |                                     |                                                                    |                            | 2013                          |
| Lebanon                                             | Publication (31)                                       | 18.6                                          | 628                                 | Comprehensive, (hospital laboratory)                               | 2000–2009                  | 2011                          |
| Lebanon                                             | Publication (32)                                       | 33 (ctx);<br>24 (caz)                         | 3811                                | Clinical isolates                                                  | 2010–2011                  | 2012                          |
| Lebanon                                             | National data from international publication (1)       | 25                                            | 36                                  | Invasive isolates                                                  | (2003)–2005                | 2008                          |
| Libya                                               | No information obtained for this report                |                                               |                                     |                                                                    |                            |                               |
| Morocco                                             | National data                                          | 78                                            | 17                                  | Comprehensive (hospital samples)                                   | 2012                       | 2013                          |
| Morocco                                             | Publication (33)                                       | 21.7 (caz);<br>31.9 (cro)                     | 32                                  | Intensive care unit                                                | (2004)–2008                | 2009                          |
| Morocco                                             | National data from international publication (1)       | 33                                            | 52                                  | Invasive isolates                                                  | (2003)–2005                | 2008                          |
| Morocco                                             | Publication (34)                                       | 8.8                                           | 80                                  | Urinary isolates (children)                                        | (2005)–2009                | 2010                          |
| Morocco                                             | Publication (35)                                       | 15                                            | 221                                 | Urinary isolates                                                   | 2005–2007                  | 2010                          |
| Morocco                                             | Publication (36)                                       | 2                                             | 192                                 | Urinary isolates                                                   | 2001–2005                  | 2010                          |
| Morocco                                             | Publication (37)                                       | 1.3                                           | 767                                 | Urinary isolates                                                   | 2004–2009                  | 2011                          |
| Oman                                                | National data                                          | 63                                            | 1360                                | Comprehensive                                                      | 2012                       | 2013                          |
| Pakistan                                            | National data, incomplete                              | 10                                            |                                     | Targeted                                                           |                            | 2013                          |
| Pakistan                                            | Publication (38)                                       | 12.6 <sup>h</sup>                             | 670                                 | Clinical isolates children                                         | 2011–2012                  | 2012                          |
| Pakistan                                            | Publication (39)                                       | 94                                            | 110                                 | Intensive care unit                                                | 2007                       | 2010                          |
| Pakistan                                            | Publication (40)                                       | 42                                            | 50                                  | Laboratory isolates                                                | 2006                       | 2009                          |
| Pakistan                                            | Publication (41)                                       | 62.3 (ctx);<br>71.7 (caz);<br>71.7 (cro)      | 53                                  | Medical intensive care                                             | 2007–2008                  | 2010                          |
| Pakistan                                            | Publication (42)                                       | 46.3                                          | 296                                 | Urinary isolates                                                   | (2002)–2005                | 2010                          |
| Pakistan                                            | Publication (43)                                       | 62.8                                          | 38                                  | Urinary isolates                                                   | (2004)–2006                | 2008                          |
| Pakistan                                            | Publication (44)                                       | 84.2                                          | 101                                 | Urinary isolates (hospitalized patients)                           | 2006–2007                  | 2011                          |
| Pakistan                                            | Publication (45)                                       | 30                                            | 180                                 | Urinary isolates                                                   |                            | 2010                          |
| Pakistan                                            | Publication (46)                                       | 88                                            | 100                                 | Urinary isolates (hospitalized patients)                           |                            | 2011                          |
| Pakistan                                            | Publication (47)                                       | 26.1 (ctx);<br>29.6 (caz)                     | 144                                 | Vaginal swabs                                                      | (2004)–2006                | 2008                          |
| Pakistan                                            | Publication (48)                                       | 51                                            | 59                                  | Urinary isolates                                                   |                            | 2011                          |
| Qatar                                               | Publication (49)                                       | 27.8                                          | 97                                  | Blood isolates                                                     | 2007–2008                  | 2010                          |
| Saudi Arabia                                        | Publication (50)                                       | 18.3 <sup>9</sup>                             | 20 268                              | Clinical isolates                                                  | (2007)–2011                | 2012                          |
| Saudi Arabia                                        | Publication (51)                                       | 33.3                                          | 339                                 | Urinary isolates (hospital)                                        | 2009–2011                  | 2013                          |
| Saudi Arabia                                        | Publication (52)                                       | Community 8.1; Hospital; 7.4 <sup>9</sup>     | Community 2508; Hospital; 71.4      | Urinary isolates (community and hospital patients)                 |                            | 2009                          |
| Saudi Arabia                                        | Publication (53)                                       | 61                                            | 392 (entire period)                 | Laboratory collection of gram-negatives                            | (2004)–2009                | 2010                          |
| Saudi Arabia                                        | Publication (54)                                       | 5.2                                           | 166                                 | Urine samples (non-hospitalized children)                          | 2003–2009                  | 2012                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                   | Resistance (%)                                                                   | No. tested isolates                           | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Saudi Arabia                                        | Publication (55)                                 | 15.7 Hospitalized patients; 4.8 (outpatients) <sup>h</sup>                       | 690 Hospitalized patients; 4813 (outpatients) | Laboratory                                               | 2004–2005                  | 2009                          |
| Saudi Arabia                                        | Publication (56)                                 | 19.5 (caz); 23.8 (cro)                                                           | 308 (caz); 294 (cro)                          | Isolates from different hospitals                        | 2010–2011                  | 2012                          |
| Saudi Arabia                                        | Publication (57)                                 | 49                                                                               | 39                                            | Laboratory records                                       | 2009                       | 2010                          |
| Saudi Arabia                                        | Publication (58)                                 | 10.4 (cro); 15 (caz)                                                             | 173                                           | Urine samples (paediatric)                               | 2003–2006                  | 2008                          |
| Somalia                                             | No information obtained for this report          |                                                                                  |                                               |                                                          |                            |                               |
| Sudan                                               | National data not available                      |                                                                                  |                                               |                                                          |                            | 2013                          |
| Sudan                                               | Publication (59)                                 | 64 (cro); 35 (caz)                                                               | 232                                           | Hospital samples                                         | 2011                       | 2012                          |
| Syrian Arab Republic                                | National data not available                      |                                                                                  |                                               |                                                          |                            | 2013                          |
| Syrian Arab Republic                                | Publication (60)                                 | 48 (cro); 49 (ctx); 52.3 (caz)                                                   | 107                                           | Urinary isolates                                         | 2011                       | 2012                          |
| Tunisia                                             | Publication (61)                                 | 21                                                                               | 15 175                                        | Hospital samples                                         | (1999)–2005                | 2008                          |
| Tunisia                                             | National data from international publication (1) | 11                                                                               | 194                                           | Invasive isolates                                        | (2003)–2005                | 2008                          |
| Tunisia                                             | Publication (36)                                 | 2                                                                                | 192                                           | Urinary isolates                                         | 2001–2005                  | 2010                          |
| Tunisia                                             | Publication (62)                                 | 5                                                                                | 43                                            | Urinary isolates (children)                              | 2009                       | 2011                          |
| United Arab Emirates                                | National data <sup>i</sup>                       | 22                                                                               | 5276                                          | Comprehensive                                            | 2012                       | 2013                          |
| United Arab Emirates                                | Publication (63)                                 | 26.7 <sup>j</sup>                                                                | 1355                                          | Clinical isolates                                        | (1994 and) 2005            | 2009                          |
| United Arab Emirates                                | Publication (64)                                 | 39                                                                               | 83                                            | Hospitalized patients                                    | 2005–2006                  |                               |
| Yemen                                               | No information obtained for this report          |                                                                                  |                                               |                                                          |                            |                               |
| International network                               | ANSORP <sup>k</sup>                              | Blood isolates: 17.9 (caz); 28.3 (ctx); Urinary isolates: 18.5 (caz); 30.3 (ctx) | 374 Blood isolates; 621 Urinary isolates      | Blood isolates and urinary isolates                      | 2012                       | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

f. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

g. Data only on proportion producing ESBL (extended spectrum beta-lactamases).

h. Data only on resistance caused by AmpC beta-lactamase.

i. Data from United Arab Emirates originate from Abu Dhabi only.

j. Aggregated from three hospitals that reported 15.8%, 18% and 62%, respectively.

k. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.4 *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>**  
European Region

| Countries, territories and other areas or groupings | Data source <sup>b,c,d</sup>                         | Resistance (%)                                                                  | No. tested isolates                       | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Albania                                             | National data not available                          |                                                                                 |                                           |                                                          |                            | 2013                          |
| Andorra                                             | No information obtained for this report              |                                                                                 |                                           |                                                          |                            |                               |
| Armenia                                             | National data not available                          |                                                                                 |                                           |                                                          |                            | 2013                          |
| Austria                                             | National data                                        | 9.1                                                                             | 3160                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Azerbaijan                                          | National data not available                          |                                                                                 |                                           |                                                          |                            | 2013                          |
| Belarus                                             | No information obtained for this report <sup>e</sup> |                                                                                 |                                           |                                                          |                            |                               |
| Belgium                                             | National data                                        | 6                                                                               | 3985                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Bosnia and Herzegovina                              | Publication (65)                                     | 1.5                                                                             | 21 918                                    | Urinary isolates (outpatients)                           | (2001)–2003 <sup>f</sup>   | 2010                          |
| Bosnia and Herzegovina                              | Publication (66)                                     | 1.1                                                                             | 1618                                      | Urinary tract infections (community)                     | 2004                       | 2010                          |
| Bulgaria                                            | National data                                        | 22.9                                                                            | 179                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Croatia                                             | National data                                        | 6                                                                               | 19 274                                    | Comprehensive                                            | 2012                       | 2013                          |
| Cyprus                                              | National data                                        | 36.2                                                                            | 138                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Czech Republic                                      | National data                                        | 11.4                                                                            | 2684                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Denmark                                             | National data                                        | 8.5                                                                             | 2532                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Estonia                                             | National data                                        | 12.2                                                                            | 90                                        | Invasive isolates                                        | 2011                       | 2013                          |
| Finland                                             | National data                                        | 5.1                                                                             | 2419                                      | Invasive isolates                                        | 2011                       | 2013                          |
| France                                              | National data                                        | 8.2                                                                             | 8479                                      | Invasive isolates                                        | 2011                       | 2009                          |
| Georgia                                             | National data not available                          |                                                                                 |                                           |                                                          |                            | 2013                          |
| Georgia                                             | Publication (67)                                     | 9                                                                               | 11                                        | Blood isolates (neonates)                                | 2003–2004                  | 2009                          |
| Germany                                             | National data                                        | 8                                                                               | 3642                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Greece                                              | National data                                        | 14.9                                                                            | 1435                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Hungary                                             | National data                                        | 15.1                                                                            | 1224                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Iceland                                             | National data                                        | 6.2                                                                             | 130                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Ireland                                             | National data                                        | 9                                                                               | 2166                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Israel                                              | Publication (68)                                     | 4.6 (community); 7.7 (hospital); 0 (long-term care facility, LTCF) <sup>g</sup> | 174 (community); 56 (hospital); 13 (LTCF) | Bacteremia (community, hospital, LTCF)                   | 2001–2006                  | 2009                          |
| Israel                                              | Publication (69)                                     | 2.2                                                                             | 1560 (all years)                          | Blood isolates                                           | (1997)–2004                | 2008                          |
| Israel                                              | Publication (70)                                     | 0                                                                               | 94                                        | Intra-abdominal infections                               | 1995–2004                  | 2009                          |
| Italy                                               | National data                                        | 19.8                                                                            | 1870                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Kazakhstan                                          | No information obtained for this report <sup>e</sup> |                                                                                 |                                           |                                                          |                            |                               |
| Kyrgyzstan                                          | National data not available                          |                                                                                 |                                           |                                                          |                            | 2013                          |
| Latvia                                              | National data                                        | 15.9                                                                            | 132                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Lithuania                                           | National data                                        | 7                                                                               | 385                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Luxembourg                                          | National data                                        | 8.2                                                                             | 353                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Malta                                               | National data                                        | 12.8                                                                            | 219                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Monaco                                              | No information obtained for this report              |                                                                                 |                                           |                                                          |                            |                               |
| Montenegro                                          | National data not available                          |                                                                                 |                                           |                                                          |                            | 2013                          |
| Netherlands                                         | National data                                        | 5.7                                                                             | 4408                                      | Invasive isolates                                        | 2011                       | 2011                          |
| Norway                                              | National data                                        | 3.6                                                                             | 2523                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Poland                                              | National data                                        | 11.7                                                                            | 938                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Portugal                                            | National data                                        | 11.3                                                                            | 1901                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Republic of Moldova                                 | National data                                        | 28                                                                              | 4788                                      |                                                          | 2012                       | 2013                          |
| Romania                                             | National data                                        | 22                                                                              | 91                                        | Invasive isolates                                        | 2011                       | 2013                          |
| Russian Federation                                  | National data                                        | 13.1 (caz); 22.9 (ctx) <sup>h</sup>                                             | 761                                       | Hospital samples, community urinary isolates             | 2011–2012                  | 2013                          |
| San Marino                                          | No information obtained for this report              |                                                                                 |                                           |                                                          |                            |                               |
| Serbia                                              | National data                                        | 21.3                                                                            | 145                                       | Invasive isolates                                        | 2012                       | 2013                          |
| Slovakia                                            | National data                                        | 31                                                                              | 738                                       | Invasive isolates                                        | 2011                       | 2013                          |
| Slovenia                                            | National data                                        | 8.8                                                                             | 1002                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Spain                                               | National data                                        | 12                                                                              | 5600                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Sweden                                              | National data                                        | 3                                                                               | 3939                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Switzerland                                         | National data                                        | 8.2                                                                             | 68 965                                    | Comprehensive                                            | 2012                       | 2013                          |
| Tajikistan                                          | No information obtained for this report              |                                                                                 |                                           |                                                          |                            |                               |
| The former Yugoslav Republic of Macedonia           | National data                                        | 47.4                                                                            | 19                                        | Invasive isolates                                        |                            | 2013                          |
| Turkey                                              | National data                                        | 43.3                                                                            | 1306                                      | Invasive isolates                                        | 2011                       | 2013                          |
| Turkmenistan                                        | No information obtained for this report              |                                                                                 |                                           |                                                          |                            |                               |



| Countries, territories and other areas or groupings | Data source <sup>b,c,d</sup>                         | Resistance (%)                       | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|--------------------------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Ukraine                                             | No information obtained for this report <sup>e</sup> |                                      |                     |                                                          |                            |                               |
| United Kingdom                                      | National data                                        | 9.6                                  | 5182                | Invasive isolates                                        | 2011                       | 2013                          |
| Uzbekistan                                          | No information obtained for this report              |                                      |                     |                                                          |                            |                               |
| International                                       | Publication (71)                                     | 14 (ctx);<br>14 (cro);<br>14.7 (caz) | 1491                | Intra-abdominal infections                               | 2008                       | 2011                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres participate in some RusNet projects.

f. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

g. Data only on proportion producing ESBL (extended spectrum beta-lactamases).

h. Hospital isolates: 66.4 (caz); 82.1 (ctx); Community urinary isolates: 6.5 (caz); 10.2 (ctx).

**Table A2.5 *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>           | Resistance (%)                                           | No. tested isolates                      | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------|----------------------------------------------------------|------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available              |                                                          |                                          |                                                          |                            | 2013                          |
| Bangladesh                                          | Publication (72)                         | 53.5 <sup>e</sup>                                        | 114                                      | Urinary isolates                                         | 2010–2011                  | 2013                          |
| Bangladesh                                          | Publication (73)                         | 59                                                       | 475                                      | Clinical isolates (national network)                     | 2011–2012                  | 2013                          |
| Bangladesh                                          | Publication (74)                         | 50.2 (caz); 63.1 (ctx)                                   | 203                                      | Urinary isolates (children)                              | 2009–2011                  | 2012                          |
| Bangladesh                                          | Publication (75)                         | 16.2 (caz); 12.5 (cro)                                   | 80                                       | Private facility / referred patients                     |                            | 2010                          |
| Bhutan                                              | National data                            | 16 (caz); 20.4 (cro);                                    | 410 (caz); 1405 (cro)                    | Comprehensive                                            | 2011–2012                  | 2012                          |
| Democratic People's Republic of Korea               | No information obtained for this report  |                                                          |                                          |                                                          |                            |                               |
| India                                               | National data not available <sup>f</sup> |                                                          |                                          |                                                          |                            | 2013                          |
| India                                               | Publication (76)                         | 61                                                       | 1103                                     | Blood samples                                            | 2000–2009                  | 2012                          |
| India                                               | Publication (77)                         | 25 (ctx); 37.3 (caz)                                     | 180                                      | Urinary samples (pregnant women with bacteriuria)        |                            | 2011                          |
| India                                               | Publication (78)                         | 27.8                                                     | 54                                       | Diabetic foot infections                                 | 2005                       | 2008                          |
| India                                               | Publication (79)                         | 28.7                                                     | 181                                      | Hospital isolates                                        | 2006                       | 2008                          |
| India                                               | Publication (80)                         | 40.4                                                     | 171                                      | Urinary isolates                                         |                            | 2012                          |
| India                                               | Publication (81)                         | 64.8                                                     | 250                                      | Clinical samples                                         | 2006–2007                  | 2008                          |
| India                                               | Publication (82)                         | 95                                                       | 239                                      | Healthy carriers                                         | 2011                       | 2012                          |
| India                                               | Publication (83)                         | 74.1                                                     | 46                                       | Lower resp. tract infections (hospital patients)         | 2011–2012                  | 2013                          |
| India                                               | Publication (84)                         | 60.5                                                     | 1817                                     | Intra-abdominal infections (hospital patients)           | 2009                       | 2011                          |
| India                                               | Publication (85)                         | 20                                                       | 120                                      | Urinary samples (hospital patients)                      | 2008                       | 2011                          |
| India                                               | Publication (86)                         | 87.5                                                     | 56                                       | Ventilator-associated pneumonia                          | 2004–2009                  | 2011                          |
| India                                               | Publication (87)                         | 33.5                                                     | 340                                      | Intra-abdominal infections (hospital patients)           | 2008                       | 2010                          |
| India                                               | Publication (88)                         | 84.9                                                     | 106                                      | Cancer patients (hospital patients)                      |                            | 2010                          |
| India                                               | Publication (89)                         | 60.5                                                     | 2671                                     | Urinary samples (hospital patients)                      | 2008–2009                  | 2012                          |
| India                                               | Publication (90)                         | 42 (caz); 63 (ctx); 64 (cro)                             | 307 (caz); 229 (ctx); 234 (cro)          | Hospital patients                                        | 2012                       | 2013                          |
| India                                               | Publication (91)                         | 73                                                       | 149                                      | Hospital patients                                        | 2007–2009                  | 2012                          |
| India                                               | Publication (92)                         | 74.8 (cro); 68.1 (ctx); 50 (caz); 78.6 (cfp); 86.8 (cpd) | 210                                      | Clinical samples                                         | (2004)–2005 <sup>g</sup>   | 2009                          |
| India                                               | Publication (93)                         | 56                                                       | 527                                      | Mixed hospital and outpatients                           | 2010                       | 2011                          |
| India                                               | Publication (94)                         | 20.3                                                     | 103                                      | Hospital samples, blood isolates                         | 2009–2010                  | 2010                          |
| India                                               | Publication (95)                         | 50 <sup>e</sup>                                          | 62                                       | Clinical isolates (hospitalized patients)                |                            | 2012                          |
| India                                               | Publication (96)                         | 19 (inpatients); 16 (outpatients)                        | 1054 (total)                             | Urinary isolates (hospitalized and outpatients)          | 2007                       | 2012                          |
| India                                               | Publication (97)                         | 40                                                       | 38                                       | burn unit                                                |                            | 2011                          |
| Indonesia                                           | National data not available              |                                                          |                                          |                                                          |                            | 2013                          |
| Indonesia                                           | Publication (98)                         | 10 (ctx); 13.8 (cro)                                     | 29                                       | Blood isolates                                           | 2002–2008                  | 2009                          |
| Maldives                                            | No information obtained for this report  |                                                          |                                          |                                                          |                            |                               |
| Myanmar                                             | National data                            | 68                                                       | 1444                                     | Comprehensive                                            | 2012                       | 2013                          |
| Nepal                                               | National data                            | 37.9                                                     | 140                                      | Targeted. Urinary isolates                               | 2012                       | 2013                          |
| Sri Lanka                                           | National data                            | 58.9                                                     | 117                                      | Targeted                                                 | 2009                       | 2013                          |
| Thailand                                            | National data                            | 30.5 (caz); 41.4 (cro); 42.7 (ctx)                       | 36 545 (caz); 22 236 (cro); 39 949 (ctx) | Comprehensive                                            | 2012                       | 2013                          |
| Timor-Leste                                         | National data not available              |                                                          |                                          |                                                          |                            | 2013                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                   | Resistance (%)                                                                   | No. tested isolates                      | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Timor-Leste                                         | National data, incomplete, from national laboratory <sup>h</sup> | 2                                                                                |                                          |                                                          | 2010–2012                  | 2013                          |
| International network                               | ANSORP <sup>f</sup>                                              | Blood isolates: 17.9 (caz); 28.3 (ctx); 18.5 Urinary isolates: (caz); 30.3 (ctx) | Blood isolates 374; Urinary isolates 621 | Blood isolates Urinary isolates                          | 2012                       | 2013                          |

a. caz, ceftazidim; cfp, cefoperazone; cpd, cefpodoxime; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data only on proportion producing ESBL (extended spectrum beta-lactamases).

f. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

g. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

h. Data were provided, but no formal national data compilation was available.

**Table A2.6 *Escherichia coli*: Resistance to third-generation cephalosporins<sup>a</sup>**  
Western Pacific Region

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                                                                      | Resistance (%)                                                                   | No. tested isolates                              | Type of surveillance, population or samples <sup>c</sup>       | Period for data collection | Year of publication or report |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------|----------------------------|-------------------------------|
| Australia                                           | National data                                                                                                       | 5.8 (caz); 9.6 (cro)                                                             | 1827                                             | Comprehensive                                                  | 2011                       | 2013                          |
| Brunei Darussalam                                   | National data from hospital laboratory                                                                              | 6.1 (cro); 6.8 (caz)                                                             | 1345                                             | Comprehensive                                                  | 2012                       | 2013                          |
| Cambodia                                            | National data <sup>e</sup> collected from several sources by public health institute (NIPH). Pasteur Institute (PI) | 49 (NIPH); 43 (PI)                                                               | 63 (NIPH); 122 (PI)                              | Clinical samples (NIPH); Laboratory data (mixed patients) (PI) | 2013<br>2013               | 2013<br>2013                  |
| China                                               | National data                                                                                                       | 31.3 (caz); 65.6 (cro); 70 (ctx)                                                 | 146 497 (caz); 113 892 (cro); 79 906 (ctx)       | Comprehensive                                                  | 2012                       | 2013                          |
| Cook Islands                                        | No information obtained for this report                                                                             |                                                                                  |                                                  |                                                                |                            |                               |
| Fiji                                                | National data not available                                                                                         |                                                                                  |                                                  |                                                                |                            | 2013                          |
| Fiji                                                | Institute surveillance <sup>e, f</sup>                                                                              | 12.2                                                                             | 2895                                             | Mixed samples                                                  | 2012                       | 2013                          |
| Japan                                               | National data                                                                                                       | 16.6                                                                             | 113 383                                          | Comprehensive                                                  | 2012                       | 2013                          |
| Kiribati                                            | National data                                                                                                       | 0                                                                                | 72                                               | Comprehensive                                                  | 2013                       | 2013                          |
| Lao People's Democratic Republic                    | National data                                                                                                       | 40.7                                                                             | 27                                               |                                                                | 2012–2013                  | 2013                          |
| Lao People's Democratic Republic                    | Institute surveillance                                                                                              | 38                                                                               | 21                                               | Comprehensive (Laboratory)                                     | 2011–2012                  | 2013                          |
| Malaysia                                            | National data                                                                                                       | 14.9 (caz); 18 (cro); 20 (ctx)                                                   | 28 418 (caz); 13 448 (cro); 24 880 (ctx)         | Comprehensive                                                  | 2012                       | 2013                          |
| Marshall Islands                                    | National data not available                                                                                         |                                                                                  |                                                  |                                                                |                            |                               |
| Micronesia                                          | National data                                                                                                       | 77                                                                               | 158                                              | Comprehensive                                                  | 2011                       | 2013                          |
| Mongolia                                            | Publication (99)                                                                                                    | 57.5 (ctx); 70.6 (caz)                                                           | 153                                              | Urinary infections (community)                                 |                            | 2013                          |
| Nauru                                               | No information obtained for this report                                                                             |                                                                                  |                                                  |                                                                |                            |                               |
| New Zealand                                         | National data                                                                                                       | 4.7 (Blood isolates); 2.9 (Urinary isolates)                                     | 1661 (Blood isolates); 55 888 (Urinary isolates) | Blood isolates, urinary isolates                               | 2011                       | 2013                          |
| Niue                                                | No information obtained for this report                                                                             |                                                                                  |                                                  |                                                                |                            |                               |
| Palau                                               | No information obtained for this report                                                                             |                                                                                  |                                                  |                                                                |                            |                               |
| Papua New Guinea                                    | National data                                                                                                       | 24.19                                                                            | 174                                              | Blood, stool, urine, "pus bench"                               | 2012                       | 2013                          |
| Philippines                                         | National data                                                                                                       | 26.7                                                                             | 3614                                             | Comprehensive                                                  | 2012                       | 2013                          |
| Republic of Korea                                   | National data                                                                                                       | 23.9 (caz); 24 (ctx) <sup>h</sup>                                                | 18 484                                           | Comprehensive                                                  | 2011                       | 2013                          |
| Republic of Korea                                   | National network                                                                                                    | 28                                                                               | 4628                                             | Comprehensive                                                  | 2012                       | 2013                          |
| Samoa                                               | National data                                                                                                       | 12.9                                                                             | 43                                               | Comprehensive                                                  | 2011                       | 2013                          |
| Singapore                                           | National data, incomplete <sup>i</sup>                                                                              |                                                                                  | 3940 All clinical isolates<br>510 Bacteraemia    | (i) All clinical isolates<br>(ii) Bacteraemia                  | 2012                       | 2013                          |
| Singapore                                           | Publication (100)                                                                                                   | 27                                                                               | 189                                              | Hospital laboratories                                          | 2006–2007                  | 2008                          |
| Singapore                                           | Publication (101)                                                                                                   | 20 (all); 21.7 (blood)                                                           | 6629 (all); 854 (blood)                          | Hospital network                                               | 2006–2008                  | 2010                          |
| Singapore                                           | Publication (102)                                                                                                   | 8.1                                                                              | 248                                              | Urinary isolates                                               | 2009                       | 2011                          |
| Solomon Islands                                     | National data not available                                                                                         |                                                                                  |                                                  |                                                                |                            | 2013                          |
| Tonga                                               | National data, incomplete                                                                                           | 0                                                                                |                                                  |                                                                |                            | 2013                          |
| Tuvalu                                              | No information obtained for this report                                                                             |                                                                                  |                                                  |                                                                |                            |                               |
| Vanuatu                                             | No information obtained for this report                                                                             |                                                                                  |                                                  |                                                                |                            |                               |
| Viet Nam                                            | No information obtained for this report <sup>j</sup>                                                                |                                                                                  |                                                  |                                                                |                            |                               |
| International network                               | ANSORP <sup>i</sup>                                                                                                 | Blood isolates: 17.9 (caz); 28.3 (ctx); Urinary isolates: 18.5 (caz); 30.3 (ctx) | 374 (Blood isolates); 621 (Urinary isolates)     | Blood isolates<br>Urinary isolates                             | 2012                       | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data were provided, but no formal national data compilation was available.

f. Data from three hospitals aggregated. Mixed samples – urine or "other" in one hospital, and comprehensive in two hospitals.

g. National data from different types of samples (blood, urinary, stool and "pus bench") aggregated.

h. Data aggregated from several sources: "Hospitals"; 31.4 (ctx); 31.6 (caz); "Clinics"; 12.9 (ctx); 13 (caz); "General hospitals"; 23.6 (ctx); 24 (caz).

i. No data on proportions obtained. Incidence in hospitals (i) 20.4 per 10,000 inpatient days, (ii) 2.6 per 10,000 inpatient days.

j. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.7 *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>**  
**African Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                                          | No. tested isolates                                  | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|---------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | Publication (1)                         | 2                                                       | 131                                                  | Invasive isolates                                        | (2003)–2005 <sup>e</sup>   | 2008                          |
| Angola                                              | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Benin                                               | National data                           | 34                                                      | 44                                                   | Invasive isolates                                        | 2012                       | 2013                          |
| Botswana                                            | National data not available             |                                                         |                                                      |                                                          |                            | 2013                          |
| Botswana                                            | Publication (103)                       | 25                                                      | 173                                                  | Urinary infections (hospital patients)                   | 2007–2009                  | 2013                          |
| Burkina Faso                                        | National data                           | 52.8                                                    | 213                                                  | Invasive isolates                                        | 2008–2009                  | 2013                          |
| Burundi                                             | National data                           | 16                                                      | 1645                                                 | Targeted                                                 | 2012                       | 2013                          |
| Cameroon                                            | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Cabo Verde                                          | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Central African Republic                            | National data                           | 53                                                      | 183                                                  | Comprehensive                                            | 2012                       | 2013                          |
| Chad                                                | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Congo                                               | National data                           | 30                                                      | 71                                                   | Comprehensive                                            | 2013                       | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Democratic Republic of the Congo                    | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Ethiopia                                            | National data                           | 71                                                      | 152                                                  | Comprehensive                                            | 2011–2012                  | 2013                          |
| Gabon                                               | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Gambia                                              | National data not available             |                                                         |                                                      |                                                          |                            | 2013                          |
| Ghana                                               | National data                           | 36 (lvx); 47.6 (cip)                                    | 87 (lvx); 160 (cip)                                  | Comprehensive                                            | 2013                       | 2013                          |
| Guinea                                              | National data                           | 38                                                      | 13                                                   | Comprehensive                                            | 2012                       | 2013                          |
| Guinea-Bissau                                       | National data                           | 40                                                      | 35                                                   | Comprehensive                                            | 2012                       | 2013                          |
| Kenya                                               | National data, incomplete               | 2                                                       |                                                      | Targeted                                                 | 2012                       | 2013                          |
| Kenya                                               | National network <sup>f</sup>           | 26.7                                                    | 15                                                   | Targeted                                                 | 2013                       | 2013                          |
| Kenya                                               | Publication (2)                         | 92.7 (cip); 90.0 (lvx)                                  | 109                                                  | Private hospital                                         | 2007–2009                  | 2012                          |
| Lesotho                                             | National data                           | 14                                                      | 107                                                  | Comprehensive                                            | 2011                       | 2013                          |
| Liberia                                             | National data                           | 15                                                      | 13                                                   | Targeted                                                 | 2011                       | 2013                          |
| Madagascar                                          | Publication (3)                         | 52.3                                                    | 88                                                   | Hospital isolates                                        | 2006–2008                  | 2010                          |
| Malawi                                              | National data                           | 0                                                       | 1                                                    | Comprehensive                                            | 2013                       | 2013                          |
| Mali                                                | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Mauritania                                          | National data                           | 20                                                      | 116                                                  | Comprehensive                                            | 2013                       | 2013                          |
| Mauritius                                           | National data                           | 57.6                                                    | 184                                                  | Hospital samples                                         | 2012                       | 2013                          |
| Mozambique                                          | No information obtained for this report |                                                         |                                                      |                                                          |                            |                               |
| Namibia                                             | National data                           | 16                                                      | 3176                                                 | Comprehensive                                            | 2011                       | 2013                          |
| Niger                                               | National data not available             |                                                         |                                                      |                                                          |                            | 2013                          |
| Nigeria                                             | Publication (104)                       | 31.4                                                    | 35                                                   | Carriers                                                 | 2011                       | 2012                          |
| Nigeria                                             | Publication (4)                         | 10                                                      | 310                                                  | Blood isolates (children)                                | 2006–2008                  | 2010                          |
| Nigeria                                             | Publication (105)                       | 43.4 (cip); 49.7 (lvx)                                  | 1909                                                 | Urinary isolates                                         | 2005–2009                  | 2012                          |
| Nigeria                                             | Publication (106)                       | 36.3 (pfl); 41.2 (ofx); 71.3 (spx); 79 (cip)            | 80                                                   | Urinary isolates (asymptomatic students)                 |                            | 2012                          |
| Nigeria                                             | Publication (5)                         | 29 (ofx)                                                | 80                                                   | Healthy carriers                                         | (2003–2007)                | 2008                          |
| Nigeria                                             | Publication (10)                        | 24.2 (cip); 23.8 (ofl)                                  | 42                                                   | Urinary isolates                                         |                            | 2010                          |
| Nigeria                                             | Publication (107)                       | 0 (cip); 0 (ref); 4.8 (ofx); 9.6 (spx)                  | 84                                                   | Asymptomatic bacteriuria (HIV-infected)                  | 2007–2008                  | 2009                          |
| Nigeria                                             | Publication (108)                       | 9.5                                                     | 85                                                   | Urinary isolates                                         | 2007–2009                  | 2011                          |
| Nigeria                                             | Publication (109)                       | 7.1 (lvx); 14 (cip); 14.4 (mox); 28.6 (ofl); 35.7 (pef) | 62 (lvx); 122 (cip); 125 (mox); 249 (ofl); 311 (pef) | Urinary samples (mixed patients)                         | 2001–2004                  | 2009                          |
| Nigeria                                             | Publication (110)                       | 9.1                                                     | 33                                                   | Carriers                                                 | 2008–2009                  | 2012                          |
| Nigeria                                             | Publication (8)                         | 1.5                                                     | 364                                                  | Hospital acquired urinary tract infections               | 2007–2008                  | 2009                          |
| Nigeria                                             | Publication (111)                       | 0 (ofx); 0 (cip)                                        | 31                                                   | Blood isolates                                           | 2004–2009                  | 2010                          |
| Nigeria                                             | Publication (112)                       | 11 (AIDS patients); 9 (non-AIDS patients)               | 135 (AIDS patients); 154 (non-AIDS patients)         | Urinary infections (AIDS and non-AIDS patients)          | 2003–2009                  | 2010                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                        | No. tested isolates               | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|---------------------------------------|-----------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Nigeria                                             | Publication (113)                       | 2.7                                   | 37                                | Urinary infections (antenatal clinic)                    | 2007–2009                  | 2012                          |
| Nigeria                                             | Publication (12)                        | 3                                     | 32                                | Blood isolates (HIV-infected children)                   |                            | 2010                          |
| Rwanda                                              | Publication (13)                        | 31.9 (Outpatients); 57.4 (Inpatients) | 72 (Outpatients); 47 (Inpatients) | Outpatients and hospital patients                        | 2009                       | 2011                          |
| Sao Tome and Principe                               | National data not available             |                                       |                                   |                                                          |                            | 2013                          |
| Senegal                                             | No information obtained for this report |                                       |                                   |                                                          |                            |                               |
| Seychelles                                          | No information obtained for this report |                                       |                                   |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                                       |                                   |                                                          |                            |                               |
| South Africa                                        | National data not available             |                                       |                                   |                                                          |                            | 2013                          |
| South Africa                                        | Publication (114)                       | 25.6                                  | 43                                | Urinary tract infection (outpatients)                    | 2008                       | 2011                          |
| South Africa                                        | Publication (16)                        | 16.1                                  | 453                               | Urinary isolates                                         | 2005–2006                  | 2009                          |
| South Sudan                                         | National data not available             |                                       |                                   |                                                          |                            | 2013                          |
| Swaziland                                           | National data                           | 37.5                                  | 32                                | Clinical samples                                         | 2013                       | 2013                          |
| Togo                                                | No information obtained for this report |                                       |                                   |                                                          |                            |                               |
| Uganda                                              | National data                           | 0                                     | 9                                 |                                                          | 2011                       | 2013                          |
| United Republic of Tanzania                         | National data not available             |                                       |                                   |                                                          |                            | 2013                          |
| United Republic of Tanzania                         | Publication (17)                        | 0                                     | 64                                | Children with diarrhoea                                  | 2004                       | 2011                          |
| Zambia                                              | National data                           | 50.5                                  | 190                               | Targeted                                                 | 2012                       | 2013                          |
| Zimbabwe                                            | National data not available             |                                       |                                   |                                                          |                            | 2013                          |

a. cip, ciprofloxacin; gat, gatifloxacin; lvx, levofloxacin; mox, moxifloxacin; nor, norfloxacin; ofx, ofloxacin; pfl, pefloxacin; ref, rifloxacin; spx, sparfloxacin. Ciprofloxacin mostly used where not specified (a few reported on norfloxacin).

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

f. Global Disease Detection Center, Kenya/Division of Global Health Protection/Center for Global Health/ CDC (US Centers for Disease Control and Prevention).

**Table A2.8 *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>**  
**Region of the Americas**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)         | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|------------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Argentina                                           | National data                           | 7.8                    | 13 102              | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Belize                                              | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 47                     | 8259                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Brazil                                              | National data                           | 8                      | 247                 | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Canada                                              | National data                           | 26.9                   | 646                 | Sentinel hospitals                                       | 2011                       | 2013                          |
| Chile                                               | National data not available             |                        |                     |                                                          |                            | 2013                          |
| Colombia                                            | National data not available             |                        |                     |                                                          |                            | 2013                          |
| Colombia                                            | Publication (20)                        | 58 (cip); 60 (nor)     | 254                 | Urinary isolates                                         | 2005–2008                  | 2010                          |
| Costa Rica                                          | National data not available             |                        |                     |                                                          |                            | 2013                          |
| Cuba                                                | National data                           | 56                     | 179                 | Uncomplicated urinary tract infection                    | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Dominican Republic                                  | National data                           | 49                     | 2812                | Hospital samples                                         | 2009                       | 2013                          |
| Ecuador                                             | National data                           | 43.8                   | 9259                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 16.7                   | 486                 | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Guatemala                                           | National data                           | 41.8                   | 1607                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Honduras                                            | National data                           | 43.1                   | 3010                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Jamaica                                             | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Mexico                                              | National data not available             |                        |                     |                                                          |                            | 2013                          |
| Mexico                                              | Publication (115)                       | 32.6                   | 907                 | Urinary isolates                                         |                            | 2008                          |
| Mexico                                              | Publication (22)                        | 57.9 (cip); 56.7 (lvx) | 563                 | Clinical isolates (hospital)                             | 2005–2011                  | 2012                          |
| Nicaragua                                           | National data                           | 42.9                   | 271                 | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Panama                                              | National data                           | 40.2                   | 2318                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Panama                                              | National network                        | 18                     | 7422                | Comprehensive                                            | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                           | 22.1                   | 1601                | Uncomplicated urinary tract infection                    | 2010                       |                               |
| Peru                                                | National data                           | 58.5                   | 2563                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |
| Peru                                                | National network                        | 66                     | 3523                | Comprehensive                                            | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report |                        |                     |                                                          |                            |                               |
| Trinidad and Tobago                                 | Publication (116)                       | 1.6                    | 64                  | Hospitalized children                                    | 2007                       | 2010                          |
| United States of America                            | National data                           | 33.3                   | 8992                | Health-care associated infections                        | 2009–2010                  | 2013                          |
| Uruguay                                             | National data not available             |                        |                     |                                                          |                            | 2013                          |
| Uruguay                                             | Publication (24)                        | 15                     | 253                 | Urinary isolates                                         | 2007–2008                  | 2010                          |
| Venezuela (Bolivarian Republic of)                  | National data                           | 37.2                   | 4114                | Uncomplicated urinary tract infection                    | 2010                       | 2013                          |

a. cip, ciprofloxacin; gat, gatifloxacin; lvx, levofloxacin; mox, moxifloxacin; nor, norfloxacin; ofx, ofloxacin; pfl, pefloxacin; ref, reflexacin; spx, sparfloxacin. Ciprofloxacin mostly used where not specified (a few reported on norfloxacin).

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.



**Table A2.9 *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>**  
**Eastern Mediterranean Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                        | Resistance (%)         | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection |
|-----------------------------------------------------|-------------------------------------------------------|------------------------|---------------------|----------------------------------------------------------|----------------------------|
| Afghanistan                                         | No information obtained for this report               |                        |                     |                                                          |                            |
| Bahrain                                             | National data                                         | 62                     | 3759                |                                                          | 2012                       |
| Djibouti                                            | No information obtained for this report               |                        |                     |                                                          |                            |
| Egypt                                               | National data not available                           |                        |                     |                                                          |                            |
| Egypt                                               | National surveillance (Hospital network) <sup>e</sup> | 34.9                   | 315                 | Comprehensive (hospital samples)                         | 2002–2010                  |
| Iran (Islamic Republic of)                          | National data                                         | 54                     | 885                 | Invasive isolates                                        | 2012                       |
| Iraq                                                | No information obtained for this report               |                        |                     |                                                          |                            |
| Jordan                                              | National data not available                           |                        |                     |                                                          |                            |
| Jordan                                              | National data from international publication (1)      | 31                     | 52                  | Invasive isolates                                        | (2003)–2005 <sup>f</sup>   |
| Jordan                                              | Publication (28)                                      | 14.5                   | 435                 | Hospital samples (children)                              | 2008                       |
| Kuwait                                              | No information obtained for this report               |                        |                     |                                                          |                            |
| Lebanon                                             | National data not available                           |                        |                     |                                                          |                            |
| Lebanon                                             | National data from international publication (1)      | 53                     | 36                  | Invasive isolates                                        | (2003)–2005                |
| Lebanon                                             | Publication (32)                                      | 47                     | 3811                | Clinical isolates                                        | 2010–2011                  |
| Libya                                               | Publication (117)                                     | 7.1–17.19              | 119                 | Clinical isolates                                        |                            |
| Morocco                                             | National data                                         | 75                     | 17                  | Comprehensive (hospital infections)                      | 2012                       |
| Morocco                                             | Publication (118)                                     | 31                     | 229                 | Clinical isolates                                        | 2011–2012                  |
| Morocco                                             | Publication (35)                                      | 27                     | 221                 | Clinical isolates                                        | 2005–2007                  |
| Morocco                                             | National data from international publication (1)      | 24                     | 62                  | Invasive isolates                                        | (2003)–2005                |
| Morocco                                             | Publication (36)                                      | 10                     | 192                 | Urinary isolates                                         | 2001–2005                  |
| Oman                                                | National data                                         | 21                     | 1360                | Comprehensive                                            | 2012                       |
| Pakistan                                            | National data, incomplete                             | 9                      |                     | Targeted                                                 |                            |
| Pakistan                                            | Publication (47)                                      | 21 (cip)               | 144                 | Vaginal swabs                                            | 2004–2006                  |
| Pakistan                                            | Publication (119)                                     | 15.5 (gat); 0 (lfx)    | 45                  | Laboratory isolates                                      |                            |
| Pakistan                                            | Publication (39)                                      | 91                     | 119                 | Intensive care unit (ICU)                                | 2007                       |
| Pakistan                                            | Publication (41)                                      | 75.5                   | 53                  | Medical ICU patients                                     | 2007–2008                  |
| Pakistan                                            | Publication (40)                                      | 64                     | 50                  | Laboratory isolates                                      | 2006                       |
| Pakistan                                            | Publication (42)                                      | 46.3                   | 296                 | Urinary isolates                                         | (2002)–2005                |
| Pakistan                                            | Publication (120)                                     | 38.5                   | 270                 | Hospital samples                                         |                            |
| Pakistan                                            | Publication (44)                                      | 34.6                   | 101                 | Urinary isolates (hospitalized patients)                 | 2006–2007                  |
| Pakistan                                            | Publication (120)                                     | 33.1                   | 3953                | Hospital samples                                         | 2002–2005                  |
| Qatar                                               | Publication (49)                                      | 40.2                   | 97                  | Blood isolates                                           | 2007–2008                  |
| Saudi Arabia                                        | No information obtained for this report               |                        |                     |                                                          |                            |
| Saudi Arabia                                        | Publication (51)                                      | 33.3                   | 339                 | Urinary isolates                                         | 2009–2011                  |
| Saudi Arabia                                        | Publication (120)                                     | 31.6                   | 7906                | Clinical isolates                                        | 2005                       |
| Saudi Arabia                                        | Publication (52)                                      | 74.1                   | 2530                | Urinary isolates                                         |                            |
| Saudi Arabia                                        | Publication (56)                                      | 25                     | 304                 | Isolates from different hospitals                        | 2010–2011                  |
| Saudi Arabia                                        | Publication (57)                                      | 51                     | 39                  | Laboratory records                                       | 2009                       |
| Saudi Arabia                                        | Publication (58)                                      | 22.8                   | 173                 | Urine samples (paediatric)                               | 2003–2006                  |
| Somalia                                             | No information obtained for this report               |                        |                     |                                                          |                            |
| Sudan                                               | National data not available                           |                        |                     |                                                          | 2013                       |
| Sudan                                               | Publication (59)                                      | 58.4 (cip); 55.1 (ofl) | 214                 | Hospital samples                                         | 2011                       |
| Syrian Arab Republic                                | National data not available                           |                        |                     |                                                          |                            |
| Tunisia                                             | No information obtained for this report               |                        |                     |                                                          |                            |
| Tunisia                                             | Publication (59)                                      | 10                     | 192                 | Urinary isolates                                         | 2001–2005                  |
| Tunisia                                             | Publication (121)                                     | 7.1                    | 436                 | Urinary isolates (community)                             | 1999–2009                  |
| Tunisia                                             | Publication (122)                                     | 0                      | 13                  | Materno-fetal infections                                 | 1993–2003                  |
| Tunisia                                             | National data from international publication (1)      | 15                     | 164                 | Invasive isolates                                        | (2003)–2005                |
| United Arab Emirates                                | National data <sup>h</sup>                            | 33.3                   | 6770                | Comprehensive                                            | 2012                       |
| United Arab Emirates                                | Publication (63)                                      | 27 <sup>i</sup>        | 1037                | Clinical isolates                                        | (1994)–2005                |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup> | Resistance (%)                                    | No. tested isolates                             | Type of surveillance, population or samples <sup>c</sup> | Period for data collection |
|-----------------------------------------------------|--------------------------------|---------------------------------------------------|-------------------------------------------------|----------------------------------------------------------|----------------------------|
| Yemen                                               | Publication (123)              | 84.6                                              | 52                                              | Urinary isolates                                         | 2003–2006                  |
| International network                               | ANSORP <sup>i</sup>            | 36.6 (Blood isolates);<br>40.9 (Urinary isolates) | 374 (Blood isolates);<br>621 (Urinary isolates) | Blood isolates Urinary isolates                          | 2012                       |
| International                                       | Publication (1)                | 21                                                | 5091                                            | Invasive isolates                                        | 2003–2005                  |

- a. cip, ciprofloxacin; gat, gatifloxacin; lvx, levofloxacin; mox, moxifloxacin; nor, norfloxacin; ofx, ofloxacin; pfl, pefloxacin; ref, reflexacin; spx, sparfloxacin. Ciprofloxacin mostly used where not specified (a few reported on norfloxacin).
- b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.
- c. See Annex 1 for definitions.
- d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.
- e. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.
- f. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.
- g. Variation during study period, no further details given.
- h. Data from United Arab Emirates originate from Abu Dhabi only.
- i. Data aggregated from three hospitals.
- j. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.10 *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>**  
**European Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                       | Resistance (%)                                        | No. tested isolates                                 | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Albania                                             | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Andorra                                             | No information obtained for this report              |                                                       |                                                     |                                                          |                            |                               |
| Armenia                                             | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Austria                                             | National data                                        | 22.3                                                  | 3162                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Azerbaijan                                          | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Belarus                                             | No information obtained for this report <sup>e</sup> |                                                       |                                                     |                                                          |                            |                               |
| Belgium                                             | National data                                        | 21.5                                                  | 3549                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Bosnia and Herzegovina                              | Publication (66)                                     | 7.8                                                   | 1618                                                | Community-acquired urinary tract infection               | 2004                       | 2010                          |
| Bulgaria                                            | National data                                        | 30.2                                                  | 179                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Croatia                                             | National data                                        | 14                                                    | 20 227                                              | Comprehensive                                            | 2012                       | 2013                          |
| Cyprus                                              | National data                                        | 47.4                                                  | 137                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Czech Republic                                      | National data                                        | 23.5                                                  | 2682                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Denmark                                             | National data                                        | 14.1                                                  | 3583                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Estonia                                             | National data                                        | 9.9                                                   | 312                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Finland                                             | National data                                        | 10.8                                                  | 2420                                                | Invasive isolates                                        | 2011                       | 2013                          |
| France                                              | National data                                        | 17.9                                                  | 8694                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Georgia                                             | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Georgia                                             | Publication (67)                                     | 1/11                                                  | 11                                                  | Blood isolates, neonates                                 | 2003–2004                  | 2009                          |
| Germany                                             | National data                                        | 23.7                                                  | 3636                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Greece                                              | National data                                        | 26.6                                                  | 1433                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Hungary                                             | National data                                        | 31.2                                                  | 1213                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Iceland                                             | National data                                        | 14                                                    | 121                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Ireland                                             | National data                                        | 22.9                                                  | 2153                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Israel                                              | Publication (69)                                     | 17.9                                                  | 719 (entire period)                                 | Blood isolates                                           | (1997)–2004 <sup>f</sup>   | 2008                          |
| Israel                                              | Publication (70)                                     | 0                                                     | 94                                                  | Intra-abdominal infections                               | 1995–2004                  | 2009                          |
| Italy                                               | National data                                        | 40.5                                                  | 1899                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Kazakhstan                                          | No information obtained for this report <sup>e</sup> |                                                       |                                                     |                                                          |                            |                               |
| Kyrgyzstan                                          | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Latvia                                              | National data                                        | 16.8                                                  | 131                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Lithuania                                           | National data                                        | 12.9                                                  | 381                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Luxembourg                                          | National data                                        | 24.1                                                  | 353                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Malta                                               | National data                                        | 32                                                    | 219                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Monaco                                              | No information obtained for this report              |                                                       |                                                     |                                                          |                            |                               |
| Montenegro                                          | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Netherlands                                         | National data                                        | 14.3                                                  | 4427                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Norway                                              | National data                                        | 9                                                     | 2505                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Poland                                              | National data                                        | 27.3                                                  | 1141                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Portugal                                            | National data                                        | 27.2                                                  | 1917                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Republic of Moldova                                 | National data                                        | 15.3                                                  | 4839                                                |                                                          | 2012                       | 2013                          |
| Romania                                             | National data                                        | 30.4                                                  | 46                                                  | Invasive isolates                                        | 2011                       | 2013                          |
| Russian Federation                                  | National data                                        | 71.7 (Hospital isolates);<br>15.9 (Community urinary) | 134 (Hospital isolates),<br>627 (Community urinary) | Hospital isolates and community urinary isolates         | 2011–2012                  | 2013                          |
| San Marino                                          | No information obtained for this report              |                                                       |                                                     |                                                          |                            |                               |
| Serbia                                              | National data                                        | 16                                                    | 145                                                 | Invasive isolates                                        | 2012                       | 2013                          |
| Slovakia                                            | National data                                        | 41.9                                                  | 737                                                 | Invasive isolates                                        | 2011                       | 2013                          |
| Slovenia                                            | National data                                        | 20.7                                                  | 1002                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Spain                                               | National data                                        | 34.5                                                  | 5597                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Sweden                                              | National data                                        | 7.9                                                   | 3295                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Switzerland                                         | National data                                        | 20.2                                                  | 69 940                                              | Comprehensive                                            | 2012                       | 2013                          |
| Tajikistan                                          | No information obtained for this report              |                                                       |                                                     |                                                          |                            |                               |
| The former Yugoslav Republic of Macedonia           | National data not available                          |                                                       |                                                     |                                                          |                            | 2013                          |
| Turkey                                              | National data                                        | 46.3                                                  | 1249                                                | Invasive isolates                                        | 2011                       | 2013                          |
| Turkmenistan                                        | No information obtained for this report              |                                                       |                                                     |                                                          |                            |                               |
| Ukraine                                             | No information obtained for this report <sup>e</sup> |                                                       |                                                     |                                                          |                            |                               |
| United Kingdom                                      | National data                                        | 17.5                                                  | 5564                                                | Invasive isolates                                        | 2011                       | 2013                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)            | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|---------------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Uzbekistan                                          | No information obtained for this report |                           |                     |                                                          |                            |                               |
| International                                       | Publication (71)                        | 24.1 (lvx);<br>25.5 (cip) | 1495                | Intra-abdominal infections                               | 2008                       | 2011                          |

- a. cip, ciprofloxacin; gat, gatifloxacin; lvx, levofloxacin; mox, moxifloxacin; nor, norfloxacin; ofx, ofloxacin; pfl, pefloxacin; ref, refloxacin; spx, sparfloxacin. Ciprofloxacin mostly used where not specified (a few reported on norfloxacin).
- b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.
- c. See Annex 1 for definitions.
- d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.
- e. Some centres participate in some RusNet projects.
- f. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

**Table A2.11 *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>**  
**South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                                                       | No. tested isolates                                                          | Type of surveillance, population or samples <sup>c</sup>  | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available             |                                                                      |                                                                              |                                                           |                            | 2013                          |
| Bangladesh                                          | Publication (72)                        | 65.2                                                                 | 114                                                                          | Urinary isolates                                          | 2010–2011                  | 2013                          |
| Bangladesh                                          | Publication (73)                        | 89                                                                   | 475                                                                          | Clinical isolates                                         | 2011–2012                  | 2013                          |
| Bangladesh                                          | Publication (75)                        | 7.5                                                                  | 80                                                                           | Private facility (referred patients, clinical samples)    |                            | 2010                          |
| Bhutan                                              | National data                           | 52.3 (cip);<br>36.2 (nor);<br>32.4 (ofl)                             | 132 (cip);<br>1414 (nor);<br>1023 (ofl)                                      | Comprehensive                                             | 2011–2012                  | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report |                                                                      |                                                                              |                                                           |                            |                               |
| India                                               | National data not available             |                                                                      |                                                                              |                                                           |                            | 2013                          |
| India                                               | Publication (77)                        | 35                                                                   | 180                                                                          | Urinary samples (pregnant women with bacteriuria)         |                            | 2011                          |
| India                                               | Publication (94)                        | 86.4                                                                 | 103                                                                          | Hospital samples                                          | 2009–2010                  | 2010                          |
| India                                               | Publication (124)                       | 81.8                                                                 | 46                                                                           | Lower respiratory tract infection (hospitalized patients) | 2011–2012                  | 2013                          |
| India                                               | Publication (84)                        | 49.6                                                                 | 1817                                                                         | Intra-abdominal infections (hospitalized patients)        | 2009                       | 2011                          |
| India                                               | Publication (86)                        | 71.4                                                                 | 56                                                                           | Ventilator-associated pneumonia                           | 2004–2009                  | 2011                          |
| India                                               | Publication (87)                        | 16.5                                                                 | 340                                                                          | Intra-abdominal infections (hospitalized patients)        | 2008                       | 2010                          |
| India                                               | Publication (88)                        | 77.4                                                                 | 106                                                                          | Hospitalized cancer patients                              |                            | 2010                          |
| India                                               | Publication (89)                        | 73                                                                   | 2671                                                                         | Urinary tract infections (hospitalized patients)          | 2008–2009                  | 2012                          |
| India                                               | Publication (90)                        | 65                                                                   | 461                                                                          | Hospitalized patients                                     | 2012                       | 2013                          |
| India                                               | Publication (125)                       | 4                                                                    | 1095                                                                         | Healthy carriers (community)                              | 2003–2004                  | 2008                          |
| India                                               | Publication (91)                        | 85                                                                   | 149                                                                          | Hospitalized patients                                     | 2007–2009                  | 2012                          |
| India                                               | Publication (93)                        | 62                                                                   | 527                                                                          | Hospitalized patients and outpatients                     | 2010                       | 2011                          |
| India                                               | Publication (126)                       | 80                                                                   | 669                                                                          | Hospitalized patients                                     | 2001–2006                  | 2008                          |
| India                                               | Publication (127)                       | 22.7                                                                 | 181                                                                          | Hospitalized patients                                     | 2003                       | 2008                          |
| India                                               | Publication (128)                       | 32                                                                   | 205                                                                          | Hospitalized patients                                     | 2011                       | 2012                          |
| India                                               | Publication (96)                        | 46 (hospitalized);<br>34 (outpatients)                               | 1054 (total)                                                                 | Urinary isolates (hospitalized and outpatients)           | 2007                       | 2012                          |
| Indonesia                                           | National data not available             |                                                                      |                                                                              |                                                           |                            | 2013                          |
| Indonesia                                           | Publication (98)                        | 17.3                                                                 | 29                                                                           | Blood isolates                                            | 2002–2008                  | 2009                          |
| Maldives                                            | No information obtained for this report |                                                                      |                                                                              |                                                           |                            |                               |
| Myanmar                                             | National data                           | 55                                                                   | 1348                                                                         | Comprehensive                                             | 2012                       | 2013                          |
| Nepal                                               | National data                           | 64.3                                                                 | 140                                                                          | Targeted                                                  | 2012                       | 2013                          |
| Sri Lanka                                           | National data                           | 58.8                                                                 | 102                                                                          | Targeted                                                  | 2009                       | 2013                          |
| Thailand                                            | National data                           | 50.9 (cip);<br>51 (lvx);<br>52.9 (ofl);<br>55.3 (nor);<br>67.2 (mox) | 31 761 (cip);<br>14 566 (lvx);<br>2904 (ofl);<br>16 335 (nor);<br>1670 (mox) | Comprehensive                                             | 2012                       | 2013                          |
| Timor-Leste                                         | National data not available             |                                                                      |                                                                              |                                                           |                            | 2013                          |
| International network                               | ANSORP <sup>e</sup>                     | 36.6 (Blood isolates);<br>40.9 (Urinary isolates)                    | 374 (Blood isolates);<br>621 (Urinary isolates)                              | Blood isolates, urinary isolates                          | 2012                       | 2013                          |

a. cip, ciprofloxacin; gat, gatifloxacin; lvx, levofloxacin; mox, moxifloxacin; nor, norfloxacin; ofx, ofloxacin; pfl, pefloxacin; ref, refloxacin; spx, sparfloxacin. Ciprofloxacin mostly used where not specified (a few reported on norfloxacin).

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.12 *Escherichia coli*: Resistance to fluoroquinolones<sup>a</sup>**  
**Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                                                                        | Resistance (%)                                    | No. tested isolates                             | Type of surveillance, population or samples <sup>c</sup>                                                   | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------|
| Australia                                           | National data                                                                                                         | 10.6                                              | 1827                                            | Comprehensive                                                                                              | 2011                       | 2013                          |
| Brunei Darussalam                                   | National data from hospital laboratory                                                                                | 12                                                | 1358                                            | Comprehensive                                                                                              | 2012                       | 2013                          |
| Cambodia                                            | National data <sup>e</sup> collected from several sources by public health institute (NIPH)<br>Pasteur Institute (PI) | 52 (NIPH);<br>82 (PI)                             | 63 (NIPH);<br>122 (PI)                          | Clinical samples and surveillance of respiratory infections (NIPH)<br>Laboratory data (mixed patients, PI) | 2013<br>2013               | 2013<br>2013                  |
| China                                               | National data                                                                                                         | 53.2 (lvx);<br>56.9 (cip)                         | 129 240 (lvx);<br>135 736 (cip)                 | Comprehensive                                                                                              | 2012                       | 2013                          |
| Cook Islands                                        | No information obtained for this report                                                                               |                                                   |                                                 |                                                                                                            |                            |                               |
| Fiji                                                | National information not available                                                                                    |                                                   |                                                 |                                                                                                            |                            | 2013                          |
| Fiji                                                | Institute surveillance <sup>e, f</sup>                                                                                | 11.9                                              | 2566                                            | Mixed samples                                                                                              | 2012                       | 2013                          |
| Japan                                               | National data                                                                                                         | 34.3                                              | 136 288                                         | Comprehensive                                                                                              | 2012                       | 2013                          |
| Kiribati                                            | National data                                                                                                         | 3                                                 | 72                                              | Comprehensive                                                                                              | 2013                       | 2013                          |
| Lao People's Democratic Republic                    | National data                                                                                                         | 53.7                                              | 41                                              |                                                                                                            | 2012–2013                  | 2013                          |
| Malaysia                                            | National data                                                                                                         | 23                                                | 27 168                                          | Comprehensive                                                                                              | 2012                       | 2013                          |
| Marshall Islands                                    | National data                                                                                                         | 13                                                | 202                                             |                                                                                                            | 2011–2012                  | 2013                          |
| Micronesia                                          | National data                                                                                                         | 16                                                | 158                                             | Comprehensive                                                                                              | 2011                       | 2013                          |
| Mongolia                                            | Publication (99)                                                                                                      | 64.7                                              | 153                                             | Community-acquired infections                                                                              | 2011                       | 2013                          |
| Nauru                                               | No information obtained for this report                                                                               |                                                   |                                                 |                                                                                                            |                            |                               |
| New Zealand                                         | National data                                                                                                         | 7.5 (Blood isolates);<br>6.5 (Urinary isolates)   | 1711 (Blood);<br>84 301 (Urine)                 | Blood isolates; Urinary isolates                                                                           | 2011                       | 2013                          |
| Niue                                                | No information obtained for this report                                                                               |                                                   |                                                 |                                                                                                            |                            |                               |
| Palau                                               | No information obtained for this report                                                                               |                                                   |                                                 |                                                                                                            |                            |                               |
| Papua New Guinea                                    | National data <sup>g</sup>                                                                                            | 13.3                                              | 526                                             | Blood, stool, urine, "pus bench"                                                                           | 2012                       | 2013                          |
| Philippines                                         | National data                                                                                                         | 40.9                                              | 3687                                            | Comprehensive                                                                                              | 2012                       | 2013                          |
| Republic of Korea                                   | National data <sup>h</sup>                                                                                            | 40.4                                              | 18 480                                          | Comprehensive                                                                                              | 2011                       | 2013                          |
| Republic of Korea                                   | National network                                                                                                      | 43                                                | 4628                                            | Comprehensive (Nosocomial infections)                                                                      | 2012                       | 2013                          |
| Samoa                                               | National data                                                                                                         | 13.9                                              | 43                                              | Comprehensive                                                                                              | 2011                       | 2013                          |
| Singapore                                           | National data, incomplete <sup>i</sup>                                                                                |                                                   | (i) 6442<br>(ii) 773                            | (i) All clinical isolates<br>(ii) Bacteraemia                                                              | 2011                       | 2013                          |
| Singapore                                           | Publication (100)                                                                                                     | 41.8                                              | 189                                             | Hospital laboratories                                                                                      | 2006–2007                  | 2008                          |
| Singapore                                           | Publication (102)                                                                                                     | 24.4                                              | 248                                             | Urinary isolates                                                                                           | 2009                       | 2011                          |
| Singapore                                           | Publication (101)                                                                                                     | 38.7 (all);<br>31 (blood)                         | 12 081 (all);<br>1285 (blood)                   | Hospital network                                                                                           | 2006–2008                  | 2010                          |
| Solomon Islands                                     | National data                                                                                                         | 95.6                                              | 115                                             |                                                                                                            | 2012                       | 2013                          |
| Tonga                                               | National data, incomplete                                                                                             | 21                                                |                                                 |                                                                                                            | 2012                       | 2013                          |
| Tuvalu                                              | No information obtained for this report                                                                               |                                                   |                                                 |                                                                                                            |                            |                               |
| Vanuatu                                             | No information obtained for this report                                                                               |                                                   |                                                 |                                                                                                            |                            |                               |
| Viet Nam                                            | Publication (129)                                                                                                     | 0.2                                               | 818                                             | Carriers (healthy children)                                                                                | 2007                       | 2012                          |
| International network                               | ANSORP <sup>j</sup>                                                                                                   | 36.6 (blood isolates);<br>40.9 (Urinary isolates) | 374 (blood isolates),<br>621 (urinary isolates) | Blood isolates, Urinary isolates                                                                           | 2012                       | 2013                          |

a. cip, ciprofloxacin; gat, gatifloxacin; lvx, levofloxacin; mox, moxifloxacin; nor, norfloxacin; ofx, ofloxacin; pfl, pefloxacin; ref, rifloxacin; spx, sparfloxacin. Ciprofloxacin mostly used where not specified (a few reported on norfloxacin).

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data were provided, but no formal national data compilation was available.

f. Data from three hospitals aggregated.

g. National data from different types of samples (blood, stool, urine and «pus bench») aggregated.

h. Data aggregated from several sources: «Hospitals» 47.5%; «Clinics»; 30%; «General hospitals» 39.5%.

i. No data on proportions obtained. Incidence in hospitals (i) 36.3 per 10,000 inpatient-days (ii) 4.5 per 10,000 inpatient-days.

j. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.13 *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>  
African Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                           | No. tested isolates   | Type of surveillance, population or samples <sup>c</sup> | Period for data collection   | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|------------------------------------------|-----------------------|----------------------------------------------------------|------------------------------|-------------------------------|
| Algeria                                             | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Angola                                              | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Benin                                               | National data                           | 41                                       | 54                    | Invasive isolates                                        | 2012                         | 2013                          |
| Botswana                                            | National data                           | 62.2 (ctx);<br>78.6 (caz)                | 37 (ctx);<br>14 (caz) | Invasive isolates                                        | 2012                         | 2013                          |
| Burkina Faso                                        | National data                           | 55.2                                     | 116                   | Invasive isolates                                        | 2008–2009                    | 2013                          |
| Burundi                                             | National data                           | 12                                       | 50                    | Targeted                                                 | 2012                         | 2013                          |
| Cameroon                                            | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Cabo Verde                                          | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Central African Republic                            | National data                           | 65                                       | 43                    | Comprehensive                                            | 2012                         | 2013                          |
| Chad                                                | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Comoros                                             | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Congo                                               | National data                           | 67.4                                     | 43                    | Comprehensive                                            | 2012                         | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Democratic Republic of the Congo                    | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Equatorial Guinea                                   | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Eritrea                                             | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Ethiopia                                            | National data                           | 14 (caz);<br>20 (cro)                    | 48                    | Comprehensive                                            | 2011–2012                    | 2013                          |
| Gabon                                               | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Gambia                                              | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Ghana                                               | National data                           | 32.1 (ctx);<br>34.7 (cro)                | 53 (ctx);<br>44 (cro) | Comprehensive                                            | 2013                         | 2013                          |
| Guinea                                              | National data                           | 25                                       | 4                     | Comprehensive                                            | 2013                         | 2013                          |
| Guinea-Bissau                                       | National data                           | 55 (ctx);<br>100 (cro)                   | 17                    | Comprehensive                                            | 2013                         | 2013                          |
| Kenya                                               | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Lesotho                                             | National data                           | 10                                       | 39                    |                                                          | 2011                         | 2013                          |
| Liberia                                             | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Madagascar                                          | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Malawi                                              | National data not available             | 0                                        | 0                     | Comprehensive                                            |                              | 2013                          |
| Mali                                                | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Mauritania                                          | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Mauritius                                           | National data                           | 54.8                                     | 104                   | Hospital isolates                                        | 2012                         | 2013                          |
| Mozambique                                          | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Namibia                                             | National data                           | 8                                        | 996                   | Comprehensive                                            | 2012                         | 2013                          |
| Niger                                               | National data not available             |                                          |                       |                                                          |                              |                               |
| Nigeria                                             | Publication (6)                         | 51.6 (cro);<br>45.2 (caz);<br>69.3 (ctx) | 62                    | Clinical samples                                         | 2007                         | 2009                          |
| Nigeria                                             | Publication (130)                       | 51 (cro);<br>39 (caz)                    | 81                    | Hospital infections                                      | 2007–2010                    | 2012                          |
| Nigeria                                             | Publication (5)                         | 17                                       | 70                    | Healthy carriers                                         | (2003)–<br>2007 <sup>e</sup> | 2008                          |
| Nigeria                                             | Publication (11)                        | 9 <sup>f</sup>                           | 60                    | Urine and stool samples (HIV/AIDS-patients)              | 2009–2010                    | 2011                          |
| Rwanda                                              | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Sao Tome & Principe                                 | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Senegal                                             | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Seychelles                                          | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Sierra Leone                                        | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| South Africa                                        | National data                           | 77                                       | 923                   | Blood cultures                                           | 2012                         | 2013                          |
| South Sudan                                         | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Swaziland                                           | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| Togo                                                | No information obtained for this report |                                          |                       |                                                          |                              |                               |
| Uganda                                              | National data                           | 50                                       | 4                     | Comprehensive                                            | 2012                         | 2013                          |
| United Republic of Tanzania                         | National data not available             |                                          |                       |                                                          |                              | 2013                          |
| United Republic of Tanzania                         | Publication (131)                       | 8                                        | 10                    | Surgical site infections                                 | 2009–2010                    | 2011                          |
| Zambia                                              | National data                           | 50                                       | 36                    |                                                          | 2012                         | 2013                          |
| Zimbabwe                                            | National data not available             |                                          |                       |                                                          |                              | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

f. Data only on proportion producing ESBL (extended spectrum beta-lactamases).



**Table A2.14 *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**Region of the Americas**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)        | No. tested isolates     | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|-----------------------|-------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Argentina                                           | National data                           | 65                    | 1622                    | Hospital isolates                                        | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Belize                                              | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 49                    | 1176                    | Hospital isolates                                        | 2010                       | 2013                          |
| Brazil                                              | National data not available             |                       |                         |                                                          |                            | 2013                          |
| Brazil                                              | Publication (132)                       | 55.6                  | 81                      | Blood isolates                                           | 2004–2006                  | 2009                          |
| Canada                                              | National data                           | 4                     | 226                     | Sentinel hospitals                                       | 2011                       |                               |
| Chile                                               | National data not available             |                       |                         |                                                          |                            | 2013                          |
| Colombia                                            | National data                           | 30 (caz);<br>32 (ctx) | 4561                    | Hospital isolates                                        | 2010                       | 2013                          |
| Costa Rica                                          | National data not available             |                       |                         |                                                          |                            | 2013                          |
| Cuba                                                | National data                           | 8 (ctx);<br>9 (caz)   | 39                      | Hospital isolates                                        | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Dominican Republic                                  | National data                           | 40                    | 2021                    | Hospital isolates                                        | 2009                       | 2009                          |
| Ecuador                                             | National data                           | 60 (caz);<br>62 (ctx) | 933                     | Hospital isolates                                        | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 67 (ctx);<br>71 (caz) | 490                     | Hospital isolates                                        | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Guatemala                                           | National data                           | 30 (caz);<br>31 (ctx) | 2884                    | Hospital isolates                                        | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Honduras                                            | National data                           | 60 (ctx);<br>70 (caz) | 920                     | Hospital isolates                                        | 2010                       | 2013                          |
| Jamaica                                             | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Mexico                                              | National data not available             |                       |                         |                                                          |                            |                               |
| Mexico                                              | Publication (133)                       | 37 (cro);<br>38 (caz) | 150                     | Clinical isolates                                        | 2006–2009                  | 2010                          |
| Nicaragua                                           | National data                           | 66                    | 234                     | Hospital isolates                                        | 2010                       | 2013                          |
| Panama                                              | National data                           | 14 (ctx);<br>26 (caz) | 2260                    | Hospital isolates                                        | 2010                       | 2013                          |
| Panama                                              | National network                        | 19                    | 1205                    | Comprehensive                                            | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                           | 61                    | 341                     | Hospital isolates                                        | 2010                       | 2013                          |
| Peru                                                | National data                           | 71                    | 498                     | Hospital isolates                                        | 2010                       | 2013                          |
| Peru                                                | National network                        | 75                    | 930                     | Comprehensive                                            | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Trinidad and Tobago                                 | No information obtained for this report |                       |                         |                                                          |                            |                               |
| Trinidad and Tobago                                 | Publication (23)                        | 15.2                  | 402                     | Clinical isolates                                        | 2004–2007                  | 2008                          |
| United States of America                            | National data                           | 23                    | 16 597                  | Health care associated infections                        | 2009–2010                  | 2013                          |
| Uruguay                                             | National data                           | 49 (ctx);<br>58 (caz) | 108 (ctx);<br>274 (caz) | Hospital isolates                                        | 2010                       | 2013                          |
| Venezuela (Bolivarian Republic of)                  | National data                           | 22 (ctx);<br>36 (caz) | 1069                    | Hospital isolates                                        | 2010                       | 2013                          |
| International                                       | Publication (25)                        | 37.7                  | 151                     | Intra-abdominal infections                               | 2008                       | 2011                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

**Table A2.15 *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>**  
Eastern Mediterranean Region

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                        | Resistance (%)                                                                                | No. tested isolates                               | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| Bahrain                                             | National data                                         | 50                                                                                            | 1166                                              | Comprehensive                                            | 2012                       | 2013                          |
| Djibouti                                            | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| Egypt                                               | National data not available                           |                                                                                               |                                                   |                                                          |                            | 2013                          |
| Egypt                                               | National surveillance (Hospital network) <sup>e</sup> | 72.2 (caz),<br>82.5 (cro)                                                                     | 594                                               | Comprehensive                                            | 2002–2010                  | 2013                          |
| Iran (Islamic Republic of)                          | National data                                         | 48                                                                                            | 110                                               | Invasive isolates                                        | 2012                       | 2013                          |
| Iraq                                                | Publication (27)                                      | 32.3 (all cephalosporins)                                                                     | 31                                                | Urinary isolates (outpatients)                           |                            | 2012                          |
| Iraq                                                | Publication (134)                                     | 17 (ctx);<br>43 (caz);<br>50 (cro)                                                            | 30                                                | Blood isolates (neonate intensive care unit [ICU])       |                            | 2013                          |
| Jordan                                              | National data not available                           |                                                                                               |                                                   |                                                          |                            | 2013                          |
| Kuwait                                              | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| Kuwait                                              | Publication (30)                                      | 20 (community);<br>33 (hospital)                                                              | 353 (community);<br>217 (hospital)                | Urinary infections: (Community and hospital acquired)    | 2005–2007                  | 2010                          |
| Lebanon                                             | National data not available                           |                                                                                               |                                                   |                                                          |                            | 2013                          |
| Lebanon                                             | Publication (32)                                      | 29 (ctx);<br>21 (caz)                                                                         | 947                                               | Hospital samples                                         | 2010–2011                  | 2012                          |
| Libya                                               | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| Morocco                                             | National data                                         | 93                                                                                            | 10                                                | Hospital infections                                      | 2013                       | 2013                          |
| Morocco                                             | Publication (33)                                      | 69.5 (caz);<br>75 (cro)                                                                       | 39                                                | ICU                                                      | 2004–2008                  | 2009                          |
| Morocco                                             | Publication (36)                                      | 20                                                                                            | 40                                                | Urinary isolates                                         | 2001–2005                  | 2010                          |
| Morocco                                             | Publication (37)                                      | 5.6                                                                                           | 36                                                | Urinary isolates                                         | 2004–2009                  | 2011                          |
| Oman                                                | National data                                         | 22                                                                                            | 425                                               | Comprehensive                                            | 2012                       | 2013                          |
| Pakistan                                            | National data, incomplete                             | 12                                                                                            |                                                   | Targeted                                                 |                            | 2013                          |
| Pakistan                                            | Publication (41)                                      | 47.2 (caz);<br>59.7 (ctx);<br>62.5 (cro)                                                      | 72                                                | Medical ICU patients                                     | 2007–2008                  | 2010                          |
| Pakistan                                            | Publication (47)                                      | 20.9 (ctx);<br>28.6 (caz)                                                                     | 77                                                | Vaginal swabs                                            | 2004–2006                  | 2008                          |
| Pakistan                                            | Publication (43)                                      | 71.4                                                                                          | 56                                                | Urinary pathogens                                        | 2004–2006                  | 2008                          |
| Pakistan                                            | Publication (135)                                     | 31.2                                                                                          | 15 914                                            | Hospital samples                                         | 2002–2007                  | 2010                          |
| Qatar                                               | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| Saudi Arabia                                        | Publication (53)                                      | 19.9 <sup>f</sup>                                                                             | 9126                                              | Clinical isolates                                        | 2007–2011                  | 2012                          |
| Saudi Arabia                                        | Publication (55) <sup>f</sup>                         | 13.7 (Hospitalized patients);<br>3.1 (outpatients)                                            | 225 (Hospitalized patients);<br>955 (outpatients) | Laboratory                                               | 2004–2005                  | 2009                          |
| Saudi Arabia                                        | Publication (57)                                      | 58 (caz);<br>59 (cro)                                                                         | 96                                                | Laboratory records                                       | 2009                       | 2010                          |
| Somalia                                             | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| Sudan                                               | National data not available                           |                                                                                               |                                                   |                                                          |                            | 2013                          |
| Syrian Arab Republic                                | National data not available                           |                                                                                               |                                                   |                                                          |                            | 2013                          |
| Tunisia                                             | Publication (61)                                      | 46                                                                                            | 4776                                              | Hospital samples                                         | 1999–2005                  | 2008                          |
| United Arab Emirates <sup>g</sup>                   | National data                                         | 17.4                                                                                          | 3075                                              | Comprehensive                                            | 2012                       | 2013                          |
| United Arab Emirates                                | Publication (64)                                      | 42                                                                                            | 45                                                | Hospitalized patients                                    | 2005–2006                  | 2008                          |
| Yemen                                               | No information obtained for this report               |                                                                                               |                                                   |                                                          |                            |                               |
| International network                               | ANSORP <sup>h</sup>                                   | Urine isolates:<br>16.6 (caz);<br>20.2 (ctx).<br>Blood isolates:<br>29.5 (caz);<br>36.4 (ctx) | 213 (Urine isolates);<br>88 (Blood isolates)      | Blood isolates and urinary infections                    | 2012                       | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

f. Data only on proportion producing ESBL (extended spectrum beta-lactamases).

g. Data from United Arab Emirates originate from Abu Dhabi only.

h. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.16 *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**European Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                       | Resistance (%)                                                                                | No. tested isolates                                      | Type of surveillance, population or samples <sup>c</sup> | Period for data collection                                  | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------|-------------------------------|
| Albania                                             | National data not available                          |                                                                                               |                                                          |                                                          |                                                             | 2013                          |
| Andorra                                             | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| Armenia                                             | National data not available                          |                                                                                               |                                                          |                                                          |                                                             | 2013                          |
| Austria                                             | National data                                        | 13.3                                                                                          | 795                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Azerbaijan                                          | National data not available                          |                                                                                               |                                                          |                                                          |                                                             | 2013                          |
| Belarus                                             | No information obtained for this report <sup>e</sup> |                                                                                               |                                                          |                                                          |                                                             |                               |
| Belgium                                             | National data                                        | 13.6                                                                                          | 668                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Bosnia and Herzegovina                              | Publication (65)                                     | 4.1                                                                                           | 1553                                                     | Urinary isolates (outpatients)                           | 2001–2003                                                   | 2010                          |
| Bosnia and Herzegovina                              | Publication, incomplete (136)                        | 50 (ctx);<br>60 (cro);<br>61.5 (caz)                                                          |                                                          | Gynaecology department                                   | 2006                                                        | 2009                          |
| Bulgaria                                            | National data                                        | 81                                                                                            | 121                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Croatia                                             | National data                                        | 34                                                                                            | 5021                                                     | Comprehensive                                            | 2012                                                        | 2013                          |
| Cyprus                                              | National data                                        | 41                                                                                            | 83                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Czech Republic                                      | National data                                        | 48.3                                                                                          | 1287                                                     | Invasive isolates                                        | 2011                                                        | 2013                          |
| Denmark                                             | National data                                        | 11.1                                                                                          | 637                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Estonia                                             | National data                                        | 39.5                                                                                          | 43                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Finland                                             | National data                                        | 3.4                                                                                           | 319                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| France                                              | National data                                        | 25.3                                                                                          | 1654                                                     | Invasive isolates                                        | 2011                                                        | 2013                          |
| Georgia                                             | National data                                        | 85.7                                                                                          | 7                                                        | Comprehensive                                            | 2012                                                        | 2013                          |
| Germany                                             | National data                                        | 12.5                                                                                          | 519                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Greece                                              | National data                                        | 75.8                                                                                          | 1665                                                     | Invasive isolates                                        | 2011                                                        | 2013                          |
| Hungary                                             | National data                                        | 53.1                                                                                          | 431                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Iceland                                             | National data                                        | 7.7                                                                                           | 26                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Ireland                                             | National data                                        | 7.6                                                                                           | 304                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Israel                                              | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| Italy                                               | National data                                        | 45.9                                                                                          | 627                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Kazakhstan                                          | No information obtained for this report <sup>e</sup> |                                                                                               |                                                          |                                                          |                                                             |                               |
| Kyrgyzstan                                          | National data not available                          |                                                                                               |                                                          |                                                          |                                                             | 2013                          |
| Latvia                                              | National data                                        | 38.5                                                                                          | 65                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Lithuania                                           | National data                                        | 60.6                                                                                          | 137                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Luxembourg                                          | National data                                        | 35.4                                                                                          | 48                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Malta                                               | National data                                        | 13.5                                                                                          | 52                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Monaco                                              | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| Montenegro                                          | National data not available                          |                                                                                               |                                                          |                                                          |                                                             | 2013                          |
| Netherlands                                         | National data                                        | 8.1                                                                                           | 720                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Norway                                              | National data                                        | 2.9                                                                                           | 421                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Poland                                              | National data                                        | 59.7                                                                                          | 278                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Portugal                                            | National data                                        | 35.4                                                                                          | 616                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Republic of Moldova                                 | National data                                        | 30.7                                                                                          | 2489                                                     |                                                          | 2012                                                        | 2013                          |
| Romania                                             | National data                                        | 44                                                                                            | 25                                                       | Invasive isolates                                        | 2011                                                        | 2013                          |
| Russian federation                                  | National data                                        | Hospital isolates:<br>87.8 (caz); 90.2 (ctx);<br>Community urinary:<br>35.2 (caz); 38.5 (ctx) | 287 (hospital isolates), 91 (Community urinary isolates) | Hospital isolates and community urinary isolates         | 2011–2012 (Hospital isolates); 2010–2011 (Urinary isolates) | 2013                          |
| San Marino                                          | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| Serbia                                              | National data                                        | 82.1                                                                                          | 100                                                      | Invasive isolates                                        | 2012–2013                                                   | 2013                          |
| Slovakia                                            | National data                                        | 68                                                                                            | 463                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Slovenia                                            | National data                                        | 30.2                                                                                          | 232                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Spain                                               | National data                                        | 13.4                                                                                          | 1145                                                     | Invasive isolates                                        | 2011                                                        | 2013                          |
| Sweden                                              | National data                                        | 2.3                                                                                           | 736                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Switzerland                                         | National data                                        | 6.8                                                                                           | 10 951                                                   | Comprehensive                                            | 2012                                                        | 2013                          |
| Tajikistan                                          | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| The former Yugoslav Republic of Macedonia           | National data                                        | 91                                                                                            | 22                                                       |                                                          |                                                             | 2013                          |
| Turkey                                              | National data                                        | 52.4                                                                                          | 794                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Turkmenistan                                        | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| Ukraine                                             | No information obtained for this report <sup>e</sup> |                                                                                               |                                                          |                                                          |                                                             |                               |
| United Kingdom                                      | National data                                        | 5.3                                                                                           | 935                                                      | Invasive isolates                                        | 2011                                                        | 2013                          |
| Uzbekistan                                          | No information obtained for this report              |                                                                                               |                                                          |                                                          |                                                             |                               |
| International                                       | Publication (71)                                     | 21.4 (ctx); 23 (caz, cro)                                                                     | 318                                                      | Intra-abdominal infections                               | 2008                                                        | 2011                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres participate in some RusNet projects.

**Table A2.17 *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                                                                 | No. tested isolates                       | Type of surveillance, population or samples <sup>c</sup>  | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available             |                                                                                |                                           |                                                           |                            | 2013                          |
| Bangladesh                                          | Publication (137)                       | 97.8 (ctx, cro); 82.2 (caz)                                                    | 45                                        | Blood isolates (neonates)                                 | 2007–2010                  | 2010                          |
| Bhutan                                              | National data                           | 33.3 (caz); 50.8 (cro)                                                         | 36 (caz); 120 (cro)                       | Comprehensive                                             | 2011–2012                  | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report |                                                                                |                                           |                                                           |                            |                               |
| India                                               | National data not available             |                                                                                |                                           |                                                           |                            | 2013                          |
| India                                               | Publication (138)                       | 100                                                                            | 62                                        | Blood isolates                                            | 2006–2008                  | 2010                          |
| India                                               | Publication (80)                        | 44.9                                                                           | 58                                        | Urinary tract infections                                  |                            | 2012                          |
| India                                               | Publication (78)                        | 20                                                                             | 80                                        | Diabetic foot infections                                  | 2005                       | 2008                          |
| India                                               | Publication (79)                        | 15.9                                                                           | 176                                       | Hospital isolates                                         | 2006                       | 2008                          |
| India                                               | Publication (139)                       | 12.5                                                                           | 144                                       | Laboratory surveillance                                   | 2005–2007                  | 2009                          |
| India                                               | Publication (82)                        | 5                                                                              | 239                                       | Healthy carriers                                          | 2011                       | 2012                          |
| India                                               | Publication (140)                       | 58 (ctx); 77 (caz); 100 (cro)                                                  | 173                                       | Blood isolates (children)                                 | 1994–2003                  | 2008                          |
| India                                               | Publication (83)                        | 76.5 (cro); 84.1 (caz)                                                         | 125                                       | Lower respiratory tract infection (hospitalized patients) | 2011–2012                  | 2013                          |
| India                                               | Publication (84)                        | 35                                                                             | 689                                       | Intra-abdominal infections (hospitalized patients)        | 2009                       | 2011                          |
| India                                               | Publication (85)                        | 60.3                                                                           | 73                                        | Urinary tract infections (hospitalized patients)          | 2008                       | 2011                          |
| India                                               | Publication (86)                        | 91.4                                                                           | 104                                       | Ventilator-associated pneumonia                           | 2004–2009                  | 2011                          |
| India                                               | Publication (141)                       | 23.7                                                                           | 65                                        | COPD <sup>e</sup> patients                                | 2002                       | 2011                          |
| India                                               | Publication (87)                        | 47.8                                                                           | 90                                        | Intra-abdominal infections (hospitalized patients)        | 2008                       | 2010                          |
| India                                               | Publication (88)                        | 75.8                                                                           | 99                                        | Cancer patients (hospitalized)                            |                            | 2010                          |
| India                                               | Publication (89)                        | 59.3                                                                           | 327                                       | Urinary tract infections (hospitalized patients)          | 2008–2009                  | 2012                          |
| India                                               | Publication (90)                        | 44.7                                                                           | 177                                       | Hospitalized patients                                     | 2012                       | 2013                          |
| India                                               | Publication (91)                        | 82                                                                             | 107                                       | Hospitalized patients                                     | 2007–2009                  | 2012                          |
| India                                               | Publication (127)                       | 16.4                                                                           | 61                                        | Hospitalized patients                                     | 2003                       | 2008                          |
| India                                               | Publication (95)                        | 50 <sup>f</sup>                                                                | 62                                        | Clinical isolates (hospitalized patients)                 |                            | 2012                          |
| India                                               | Publication (96)                        | 25 (Hospitalized); 21 (Outpatients)                                            | 239 (Hospitalized); 140 (Outpatients)     | Urinary isolates (hospitalized and outpatients)           | 2007                       | 2012                          |
| Indonesia                                           | National data not available             |                                                                                |                                           |                                                           |                            | 2013                          |
| Indonesia                                           | Publication (98)                        | 53.3 (ctx); 67.2 (cro)                                                         | 67                                        | Blood isolates                                            | 2002–2008                  | 2011                          |
| Maldives                                            | No information obtained for this report |                                                                                |                                           |                                                           |                            |                               |
| Myanmar                                             | National data                           | 60                                                                             | 268                                       | Comprehensive                                             | 2012                       | 2013                          |
| Nepal                                               | National data                           | 0                                                                              | 19                                        | Targeted                                                  | 2012                       | 2013                          |
| Nepal                                               | Publication (142)                       | 48.3                                                                           | 145                                       | Urinary isolates                                          | 2011–2012                  | 2013                          |
| Sri Lanka                                           | National data                           | 80.9                                                                           | 105                                       | Targeted                                                  | 2009                       | 2013                          |
| Thailand                                            | National data                           | 37.4 (caz); 40.3 (cro); 41.1 (ctx)                                             | 25 421 (caz); 16 502 (cro); 22 546 (ctx)  | Comprehensive                                             | 2012                       | 2013                          |
| Timor-Leste                                         | National data not available             |                                                                                |                                           |                                                           |                            | 2013                          |
| International network                               | ANSORP <sup>g</sup>                     | Urine isolates: 16.6 (caz); 20.2 (ctx). Blood isolates: 29.5 (caz); 36.4 (ctx) | 213 (Urine isolates); 88 (Blood isolates) | Blood isolates and urinary infections                     | 2012                       | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Chronic obstructive pulmonary disease.

f. Based on detection of extended-spectrum betalactamases (ESBL) only.

g. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.18 *Klebsiella pneumoniae*: Resistance to third-generation cephalosporins<sup>a</sup>**  
**Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                                                                      | Resistance (%)                                                                 | No. tested isolates                       | Type of surveillance, population or samples <sup>c</sup>                                                  | Period for data collection | Year of publication or report |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------|
| Australia                                           | National data                                                                                                       | 9.8 (caz); 12.1 (cro)                                                          | 396                                       | Comprehensive                                                                                             | 2011                       | 2013                          |
| Brunei Darussalam                                   | National data from hospital laboratory                                                                              | 6.2 (cro); 6.8 (caz)                                                           | 1038                                      | Comprehensive                                                                                             | 2012                       | 2013                          |
| Cambodia                                            | National data <sup>e</sup> collected from several sources by public health institute (NIPH); Pasteur Institute (PI) | 32 (NIPH); 31 (PI)                                                             | 63 (NIPH); 30 (PI)                        | Clinical samples and surveillance of respiratory infections (NIPH); Laboratory data (mixed patients) (PI) | 2013                       | 2013                          |
| China                                               | National data                                                                                                       | 25.1 (caz); 44.4 (cro); 52.5 (ctx)                                             | 102 420 (caz); 81 541 (cro); 55 433 (ctx) | Comprehensive                                                                                             | 2012                       | 2013                          |
| Cook Islands                                        | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| Fiji                                                | National data not available                                                                                         |                                                                                |                                           |                                                                                                           |                            | 2013                          |
| Fiji                                                | Institute surveillance <sup>e, f</sup>                                                                              | 25                                                                             | 2900                                      | Mixed samples                                                                                             | 2012                       | 2013                          |
| Japan                                               | National data                                                                                                       | 5.4                                                                            | 62 242                                    | Comprehensive                                                                                             | 2012                       |                               |
| Kiribati                                            | National data                                                                                                       | 1                                                                              | 111                                       | Comprehensive                                                                                             | 2012                       | 2013                          |
| Lao People's Democratic Republic                    | National data                                                                                                       | 0                                                                              | 3                                         |                                                                                                           | 2013                       | 2013                          |
| Lao People's Democratic Republic                    | Institute surveillance                                                                                              | 25                                                                             | 4                                         | Comprehensive (Laboratory)                                                                                | 2011–2012                  | 2013                          |
| Malaysia                                            | National data                                                                                                       | 21.1 (cro); 20.8 (caz); 24 (ctx)                                               | 23 963 (caz); 14 200 (cro); 20 030 (ctx)  | Comprehensive                                                                                             | 2012                       | 2013                          |
| Marshall Islands                                    | National data not available                                                                                         |                                                                                |                                           |                                                                                                           |                            | 2013                          |
| Micronesia                                          | National data                                                                                                       | 71                                                                             | 87                                        | Comprehensive                                                                                             | 2011                       | 2013                          |
| Mongolia                                            | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| Mongolia                                            | Publication (99)                                                                                                    | 33.7 (ctx); 34.8 (caz)                                                         | 92                                        | Community infections                                                                                      | 2011                       | 2013                          |
| Nauru                                               | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| New Zealand                                         | National data                                                                                                       | 12.7                                                                           | 416                                       | Blood isolates                                                                                            | 2011                       | 2013                          |
| Niue                                                | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| Palau                                               | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| Papua New Guinea                                    | National data                                                                                                       | 63.59                                                                          | 252                                       | Blood, urine, "pus bench"                                                                                 | 2012                       | 2013                          |
| Philippines                                         | National data                                                                                                       | 30                                                                             | 1451                                      | Comprehensive                                                                                             | 2012                       | 2013                          |
| Republic of Korea <sup>h</sup>                      | National data                                                                                                       | 44 (caz); 41.7 (ctx) <sup>i</sup>                                              | 7130 <sup>h</sup>                         | Comprehensive                                                                                             | 2011                       |                               |
| Republic of Korea                                   | National network                                                                                                    | 47                                                                             | 2421                                      | Hospital infections                                                                                       | 2012                       | 2013                          |
| Samoa                                               | National data                                                                                                       | 7.7 (cro); 19.8 (ctx)                                                          | 116                                       | Comprehensive                                                                                             | 2011                       | 2013                          |
| Singapore                                           | National data, incomplete <sup>j</sup>                                                                              |                                                                                | (i) 2806 (ii) 395                         | (i) All clinical isolates (ii) Bacteraemia                                                                | 2011                       | 2013                          |
| Singapore                                           | Publication (100)                                                                                                   | 30.8                                                                           | 198                                       | Hospital laboratories                                                                                     | 2006–2007                  | 2008                          |
| Singapore                                           | Publication (101)                                                                                                   | 32.3 (All); 27.4 (Blood isolates)                                              | 685 (Blood isolates); 6321 (All isolates) | Hospital network                                                                                          | 2006–2008                  | 2010                          |
| Solomon Islands                                     | National data                                                                                                       | 27                                                                             | 30                                        |                                                                                                           | 2012                       | 2013                          |
| Tonga                                               | National data, incomplete                                                                                           | 0                                                                              |                                           |                                                                                                           | 2012                       | 2013                          |
| Tuvalu                                              | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| Vanuatu                                             | No information obtained for this report                                                                             |                                                                                |                                           |                                                                                                           |                            |                               |
| Vietnam                                             | No information obtained for this report <sup>k</sup>                                                                |                                                                                |                                           |                                                                                                           |                            |                               |
| International network                               | ANSORP <sup>l</sup>                                                                                                 | Urine isolates: 16.6 (caz); 20.2 (ctx). Blood isolates: 29.5 (caz); 36.4 (ctx) | 213 (Urine isolates); 88 (Blood isolates) | Blood isolates and urinary infections                                                                     | 2012                       | 2013                          |

a. caz, ceftazidim; ctx, cefotaxim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data were provided, but no formal national data compilation was available.

f. Data from three hospitals aggregated.

g. National data from different types of samples (Blood, «pus bench» and urine) aggregated.

h. Data from more than one surveillance source.

i. Information aggregated from more than one surveillance system: «Hospitals»; 45.5 (ctx); 47.9 (caz); «Clinics»; 22 (ctx); 23.1 (caz); «General hospitals»; 37.9 (ctx); 39 (caz).

j. No information on proportions obtained. Incidence in hospitals: (i) 15.4 per 10,000 inpatient-days (ii) 2.1 per 10,000 inpatient-days.

k. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

l. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.19 *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>**  
**African Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)        | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|-----------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Angola                                              | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Benin                                               | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Botswana                                            | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Burkina Faso                                        | National data                           | 0                     | 20                  | Invasive isolates                                        | 2008–2009                  | 2013                          |
| Burundi                                             | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Cameroon                                            | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Cabo Verde                                          | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Central African Republic                            | National data                           | 0                     | 43                  | Comprehensive                                            |                            | 2013                          |
| Chad                                                | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Congo                                               | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Democratic Republic of the Congo                    | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Ethiopia                                            | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Gabon                                               | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Gambia                                              | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Ghana                                               | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Guinea                                              | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Guinea-Bissau                                       | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Kenya                                               | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Lesotho                                             | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Liberia                                             | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Madagascar                                          | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Malawi                                              | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Mali                                                | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Mauritania                                          | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Mauritius                                           | National data                           | 1.9                   | 104                 | Hospital isolates                                        | 2012                       | 2013                          |
| Mozambique                                          | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Namibia                                             | National data                           | 1                     | 280                 |                                                          | 2012                       | 2013                          |
| Niger                                               | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Nigeria                                             | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Rwanda                                              | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Sao Tome and Principe                               | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Senegal                                             | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Seychelles                                          | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                       |                     |                                                          |                            |                               |
| South Africa                                        | National data                           | 1 (mem);<br>3.8 (etp) | 923                 | Blood cultures                                           | 2012                       | 2013                          |
| South Sudan                                         | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Swaziland                                           | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Togo                                                | No information obtained for this report |                       |                     |                                                          |                            |                               |
| Uganda                                              | National data, incomplete               |                       | 4                   | Comprehensive                                            | 2012                       | 2013                          |
| United Republic of Tanzania                         | National data not available             |                       |                     |                                                          |                            | 2013                          |
| Zambia                                              | National data                           | 0                     | 9                   | Targeted                                                 |                            | 2013                          |
| Zimbabwe                                            | National data not available             |                       |                     |                                                          |                            | 2013                          |

a. dor, doripenem; etp, ertapenem; imi, imipenem; mem, meropenem

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

**Table A2.20 *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>**  
**Region of the Americas**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)          | No. tested isolates     | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|-------------------------|-------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Argentina                                           | National data                           | 6 (imi);<br>8 (mem)     | 1622                    | Hospital isolates                                        | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Belize                                              | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 4 (imi);<br>5 (mem)     | 1176                    | Hospital isolates                                        | 2010                       | 2013                          |
| Brazil                                              | National data not available             |                         |                         |                                                          |                            | 2013                          |
| Brazil                                              | Publication (143)                       | 0 (imi);<br>1.6 (etp)   | 63                      | Clinical isolates                                        | 2009                       | 2011                          |
| Canada                                              | National data                           | 0                       | 226                     | Sentinel hospitals                                       | 2011                       | 2013                          |
| Chile                                               | National data not available             |                         |                         |                                                          |                            | 2013                          |
| Colombia                                            | National data                           | 6 (imi);<br>7 (mem)     | 4561                    | Hospital isolates                                        | 2010                       | 2013                          |
| Costa Rica                                          | National data not available             |                         |                         |                                                          |                            | 2013                          |
| Cuba                                                | National data                           | 5 (imi);<br>6 (mem)     | 39                      | Hospital isolates                                        | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Dominican Republic                                  | National data                           | 0                       | 2021                    | Hospital isolates                                        | 2009                       | 2013                          |
| Ecuador                                             | National data                           | 2                       | 933                     | Hospital isolates                                        | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 2                       | 490                     | Hospital isolates                                        | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Guatemala                                           | National data                           | 0 (imi);<br>3 (mem)     | 2884                    | Hospital isolates                                        | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Honduras                                            | National data                           | 2                       | 920                     | Hospital isolates                                        | 2010                       | 2013                          |
| Jamaica                                             | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Mexico                                              | National data not available             |                         |                         |                                                          |                            | 2013                          |
| Nicaragua                                           | National data                           | 6 (imi);<br>9 (mem)     | 234                     | Hospital isolates                                        | 2010                       | 2013                          |
| Panama                                              | National data                           | 0 (imi);<br>1 (mem)     | 2260                    | Hospital isolates                                        | 2010                       | 2013                          |
| Panama                                              | National network                        | 3                       | 4199                    | Comprehensive                                            | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                           | 1 (imi);<br>3 (mem)     | 315 (imi);<br>577 (mem) | Hospital isolates                                        | 2010                       | 2013                          |
| Peru                                                | National data                           | 0.3                     | 319 (imi);<br>365 (mem) | Hospital isolates                                        | 2010                       | 2013                          |
| Peru                                                | National network                        | 0.4                     | 926                     | Comprehensive                                            | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Trinidad and Tobago                                 | No information obtained for this report |                         |                         |                                                          |                            |                               |
| Trinidad and Tobago                                 | Publication (116)                       | 0                       | 92                      | Hospitalized children                                    | 2007                       | 2010                          |
| United States of America                            | National data                           | 11                      | 7932                    | Health-care associated infections                        | 2009–2010                  | 2013                          |
| Uruguay                                             | National data                           | 0.7 (mem);<br>1.2 (imi) | 263 (mem);<br>249 (imi) | Hospital isolates                                        | 2010                       | 2013                          |
| Venezuela (Bolivarian Republic of)                  | National data                           | 3 (imi);<br>4 (mem)     | 1069                    | Hospital isolates                                        | 2010                       | 2013                          |
| International                                       | Publication (25)                        | 1.3                     | 151                     | Intra-abdominal infections                               | 2008                       | 2011                          |

a. dor, doripenem; etp, ertapenem; imi, imipenem; mem, meropenem

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.



**Table A2.21 *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>**  
**Eastern Mediterranean Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                        | Resistance (%)                                                                 | No. tested isolates                         | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| Bahrain                                             | National data                                         | 40                                                                             | 495                                         |                                                          | 2012                       | 2013                          |
| Djibouti                                            | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| Egypt                                               | National surveillance (Hospital network) <sup>e</sup> | 5.6                                                                            | 594                                         | Comprehensive,                                           | 2002–2010                  |                               |
| Iran (Islamic Republic of)                          | National data                                         | 54                                                                             | 35                                          | Invasive isolates                                        | 2013                       | 2013                          |
| Iraq                                                | Publication (134)                                     | 0                                                                              | 30                                          | Blood isolates (neonate intensive care unit [ICU])       |                            | 2013                          |
| Jordan                                              | National data not available                           |                                                                                |                                             |                                                          |                            | 2013                          |
| Kuwait                                              | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| Lebanon                                             | National data not available                           |                                                                                |                                             |                                                          |                            | 2013                          |
| Lebanon                                             | Publication (32)                                      | 0.7                                                                            | 947                                         | Hospital samples                                         | 2010–2011                  | 2012                          |
| Lebanon                                             | Publication (144)                                     | 1.8 (dor); 8.8 (imi)                                                           | 57                                          | Hospital samples                                         |                            | 2012                          |
| Libya                                               | Publication (117)                                     | 0                                                                              | 50                                          | Urinary isolates                                         |                            | 2010                          |
| Morocco                                             | National data                                         | 0                                                                              | 10                                          | Hospital infections                                      | 2012                       | 2013                          |
| Oman                                                | National data                                         | 0                                                                              | 425                                         | Comprehensive                                            | 2012                       | 2013                          |
| Pakistan                                            | National data, incomplete                             | 3                                                                              |                                             | Targeted                                                 |                            | 2013                          |
| Pakistan                                            | Publication (41)                                      | 20.8                                                                           | 72                                          | Medical ICU patients                                     | 2007–2008                  | 2010                          |
| Pakistan                                            | Publication (135)                                     | 0.4                                                                            | 5016                                        | Hospital samples                                         | 2002–2007                  | 2010                          |
| Pakistan                                            | Publication (47)                                      | 0                                                                              | 77                                          | Vaginal swabs                                            | 2004–2006                  | 2008                          |
| Qatar                                               | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| Saudi Arabia                                        | Publication (53)                                      | 0.4                                                                            | 285                                         | ICUs                                                     | 2004–2009                  | 2010                          |
| Saudi Arabia                                        | Publication (56)                                      | 7.8                                                                            | 128                                         | Hospital isolates                                        | 2010–2011                  | 2012                          |
| Somalia                                             | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| Sudan                                               | National data not available                           |                                                                                |                                             |                                                          |                            | 2013                          |
| Syrian Arab Republic                                | National data not available                           |                                                                                |                                             |                                                          |                            | 2013                          |
| Tunisia                                             | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| United Arab Emirates                                | National data <sup>f</sup>                            | 1.5                                                                            | 3084                                        | Comprehensive                                            | 2012                       | 2013                          |
| Yemen                                               | No information obtained for this report               |                                                                                |                                             |                                                          |                            |                               |
| International network                               | ANSORP <sup>g</sup>                                   | Blod isolates: 0.9 (etp), 1.4 (imi)<br>Urinary isolates: 5.7 (imi), 10.2 (etp) | 213 (blood isolates), 88 (urinary isolates) | Blood isolates, urinary isolates                         | 2012                       | 2013                          |

a. dor, doripenem; etp, ertapenem; imi, imipenem; mem, meropenem

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

f. Data from United Arab Emirates originate from Abu Dhabi only.

g. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.22 *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>**  
**European Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                       | Resistance (%)                                                                                          | No. tested isolates                             | Type of surveillance, population or samples <sup>c</sup> | Period for data collection                              | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------|----------------------------------------------------------|---------------------------------------------------------|-------------------------------|
| Albania                                             | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         | 2013                          |
| Andorra                                             | No information obtained for this report              |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Armenia                                             | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         | 2013                          |
| Austria                                             | National data                                        | 0.2                                                                                                     | 610                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Azerbaijan                                          | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         | 2013                          |
| Belarus                                             | No information obtained for this report <sup>e</sup> |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Belgium                                             | National data                                        | 0.3                                                                                                     | 646                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Bulgaria                                            | National data                                        | 0                                                                                                       | 116                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Croatia                                             | National data                                        | 0                                                                                                       | 4945                                            | Comprehensive                                            | 2012                                                    | 2013                          |
| Cyprus                                              | National data                                        | 15.7                                                                                                    | 83                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Czech Republic                                      | National data                                        | 0.1                                                                                                     | 1193                                            | Invasive isolates                                        | 2011                                                    | 2013                          |
| Denmark                                             | National data                                        | 0                                                                                                       | 589                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Estonia                                             | National data                                        | 0                                                                                                       | 73                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Finland                                             | National data                                        | 0                                                                                                       | 318                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| France                                              | National data                                        | 0                                                                                                       | 1640                                            | Invasive isolates                                        | 2011                                                    | 2013                          |
| Georgia                                             | National data                                        | 57.1                                                                                                    | 7                                               | Comprehensive                                            | 2012                                                    | 2013                          |
| Georgia                                             | Publication (67)                                     | 2                                                                                                       | 45                                              | Blood isolates (neonates)                                | 2003–2004                                               | 2009                          |
| Germany                                             | National data                                        | 0                                                                                                       | 512                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Greece                                              | National data                                        | 68.2                                                                                                    | 1636                                            | Invasive isolates                                        | 2011                                                    | 2013                          |
| Hungary                                             | National data                                        | 1.9                                                                                                     | 413                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Iceland                                             | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         | 2013                          |
| Ireland                                             | National data                                        | 0.3                                                                                                     | 302                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Israel                                              | Publication (145)                                    | 7                                                                                                       | 299                                             | Patient screening                                        | 2007–2008                                               | 2012                          |
| Israel                                              | Publication (146)                                    | 5.4                                                                                                     | 298                                             | Carrier screening                                        |                                                         | 2010                          |
| Italy                                               | National data                                        | 26.7                                                                                                    | 615                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Kazakhstan                                          | No information obtained for this report <sup>e</sup> |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Kyrgyzstan                                          | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         | 2013                          |
| Latvia                                              | National data                                        | 0                                                                                                       | 65                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Lithuania                                           | National data                                        | 0                                                                                                       | 19                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Luxembourg                                          | National data                                        | 0                                                                                                       | 48                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Malta                                               | National data                                        | 3.8                                                                                                     | 52                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Monaco                                              | No information obtained for this report              |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Montenegro                                          | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Netherlands                                         | National data                                        | 0.3                                                                                                     | 722                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Norway                                              | National data                                        | 0                                                                                                       | 443                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Poland                                              | National data                                        | 0.5                                                                                                     | 376                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Portugal                                            | National data                                        | 0.3                                                                                                     | 580                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Republic of Moldova                                 | National data                                        | 20.3                                                                                                    | 483                                             |                                                          | 2012                                                    | 2013                          |
| Romania                                             | National data                                        | 0                                                                                                       | 10                                              | Invasive isolates                                        | 2011                                                    | 2013                          |
| Russian Federation                                  | National data                                        | Hospital isolates: 3.1 (mem); 5.2 (imi); 18.5 (etp)<br>Community urinary: 0 (mem); 1.1 (imi); 4.4 (etp) | 287 (Hospital isolates; 91 (Community urinary)) | Hospital isolates; community urinary isolates            | Hospital isolates 2011–2012; urinary isolates 2010–2011 | 2013                          |
| San Marino                                          | No information obtained for this report              |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Serbia                                              | National data                                        | 11.2                                                                                                    | 100                                             | Invasive isolates                                        | 2012                                                    | 2013                          |
| Slovakia                                            | National data                                        | 0.7                                                                                                     | 432                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Slovenia                                            | National data                                        | 0                                                                                                       | 232                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Spain                                               | National data                                        | 0.3                                                                                                     | 1144                                            | Invasive isolates                                        | 2011                                                    | 2013                          |
| Sweden                                              | National data                                        | 0                                                                                                       | 900                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Switzerland                                         | National data                                        | 1                                                                                                       | 9433                                            | Comprehensive                                            | 2012                                                    | 2013                          |
| Tajikistan                                          | No information obtained for this report              |                                                                                                         |                                                 |                                                          |                                                         |                               |
| The former Yugoslav Republic of Macedonia           | National data                                        | 0                                                                                                       | 22                                              | Invasive isolates                                        | Invasive isolates                                       | 2013                          |
| Turkey                                              | National data not available                          |                                                                                                         |                                                 |                                                          |                                                         | 2013                          |
| Turkey                                              | Publication (147)                                    | 0/18                                                                                                    | 18                                              | Burn patients                                            |                                                         | 2013                          |
| Turkmenistan                                        | No information obtained for this report              |                                                                                                         |                                                 |                                                          |                                                         |                               |
| Ukraine                                             | No information obtained for this report <sup>e</sup> |                                                                                                         |                                                 |                                                          |                                                         |                               |
| United Kingdom                                      | National data                                        | 0.4                                                                                                     | 825                                             | Invasive isolates                                        | 2011                                                    | 2013                          |
| Uzbekistan                                          | No information obtained for this report              |                                                                                                         |                                                 |                                                          |                                                         |                               |
| International                                       | Publication (71)                                     | 4.7 (imi); 6.6 (etp)                                                                                    | 1495                                            | Intra-abdominal infections                               | 2008                                                    | 2011                          |

a. dor, doripenem; etp, ertapenem; imi, imipenem; mem, meropenem

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres participate in some RusNet projects.

**Table A2.23 *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>**  
**South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>           | Resistance (%)                                                                  | No. tested isolates                                | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available              |                                                                                 |                                                    |                                                          |                            | 2013                          |
| Bangladesh                                          | Publication (137)                        | 0                                                                               | 45                                                 | Blood isolates (neonates)                                | 2007–2010                  | 2010                          |
| Bhutan                                              | National data                            | 0                                                                               | 40                                                 | Comprehensive                                            | 2011–2012                  | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report  |                                                                                 |                                                    |                                                          |                            |                               |
| India                                               | National data not available              |                                                                                 |                                                    |                                                          |                            | 2013                          |
| India                                               | Publication (148)                        | 1.4                                                                             | 144                                                | Laboratory surveillance                                  | 2005–2007                  | 2009                          |
| India                                               | Publication (76)                         | 52                                                                              | 256                                                | Blood isolates                                           | 2000–2009                  | 2012                          |
| India                                               | Publication (94)                         | 39.4 (imi); 36.5 (mem)                                                          | 104                                                | Blood isolates                                           | (2007)–2010                | 2010                          |
| India                                               | Publication (82)                         | 0                                                                               | 239                                                | Screening (healthy carriers)                             | 2011                       | 2012                          |
| India                                               | Publication (138)                        | 29.6                                                                            | 27 (last study year)                               | Neuro intensive care unit                                | (2006)–2008                | 2010                          |
| India                                               | Publication (83)                         | 7.8                                                                             | 125                                                | Lower respiratory tract infection (hospital patients)    | 2011–2012                  | 2013                          |
| India                                               | Publication (84)                         | 7.6                                                                             | 689                                                | Intra-abdominal infections (hospital patients)           | 2009                       | 2011                          |
| India                                               | Publication (86)                         | 55                                                                              | 104                                                | Ventilator-associated pneumonia                          | 2004–2009                  | 2011                          |
| India                                               | Publication (87)                         | 14.4                                                                            | 90                                                 | Intra-abdominal infections (hospital patients)           | 2008                       | 2010                          |
| India                                               | Publication (88)                         | 0                                                                               | 99                                                 | Cancer patients (hospitalized)                           |                            | 2010                          |
| India                                               | Publication (89)                         | 18.6                                                                            | 327                                                | Urinary tract infections (hospital patients)             | 2008–2009                  | 2012                          |
| India                                               | Publication (90)                         | 2                                                                               | 177                                                | Hospital patients                                        | 2012                       | 2013                          |
| India                                               | Publication (91)                         | 2                                                                               | 107                                                | Hospital patients                                        | 2007–2009                  | 2012                          |
| India                                               | Publication (78)                         | 0                                                                               | 80                                                 | Diabetic foot infections                                 | 2005                       | 2008                          |
| Indonesia                                           | National data not available <sup>e</sup> |                                                                                 |                                                    |                                                          |                            | 2013                          |
| Maldives                                            | No information obtained for this report  |                                                                                 |                                                    |                                                          |                            |                               |
| Myanmar                                             | National data                            | 8                                                                               | 58                                                 | Comprehensive                                            | 2012                       | 2013                          |
| Nepal                                               | National data                            | 0                                                                               | 19                                                 | Urinary isolates                                         |                            | 2013                          |
| Sri Lanka                                           | National data                            | 0                                                                               | 90                                                 | Targeted                                                 | 2009                       | 2013                          |
| Thailand                                            | National data                            | 0.5 (dor); 1.3 (imi); 1.3 (mem); 2.1 (etp)                                      | 577 (dor); 21 110 (imi); 20 021 (mem); 3435 (etp); | Comprehensive                                            | 2012                       | 2013                          |
| Timor-Leste                                         | National data not available              |                                                                                 |                                                    |                                                          |                            | 2013                          |
| International network                               | ANSORP <sup>f</sup>                      | Blood isolates: 0.9 (etp); 1.4 (imi)<br>Urinary isolates: 5.7 (imi); 10.2 (etp) | 213 (Blood isolates), 88 (Urinary isolates)        | Blood isolates, urinary isolates                         | 2012                       | 2013                          |

a. dor, doripenem; etp, ertapenem; imi, imipenem; mem, meropenem

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

f. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.24 *Klebsiella pneumoniae*: Resistance to carbapenems<sup>a</sup>**  
**Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                                                                         | Resistance (%)                                                                               | No. tested isolates                                                          | Type of surveillance, population or samples <sup>c</sup>                                                    | Period for data collection     | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------|
| Australia                                           | National data                                                                                                          | 0.5 (mem);<br>1 (etp)                                                                        | 396                                                                          |                                                                                                             | 2011                           | 2013                          |
| Brunei Darussalam                                   | National data from hospital laboratory                                                                                 | 0.3 (mem);<br>0.8 (imi)                                                                      | 1038                                                                         | Comprehensive                                                                                               | 2012                           | 2013                          |
| Cambodia                                            | National data <sup>e</sup> collected from several sources by public health institute (NIPH).<br>Pasteur Institute (PI) | 3 (NIPH);<br>2.1 (PI)                                                                        | 34 (NIPH);<br>41 (PI)                                                        | Clinical samples and surveillance of respiratory infections (NIPH);<br>Laboratory data (mixed patients, PI) | 2012 (NIPH);<br>2007–2010 (PI) | 2013                          |
| China                                               | National data                                                                                                          | 7.1 (mem);<br>7.7 (imi)                                                                      | 54 671 (mem);<br>100 805 (imi)                                               | Comprehensive                                                                                               | 2012                           | 2013                          |
| Cook Islands                                        | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| Fiji                                                | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| Fiji                                                | Institute surveillance <sup>e, f</sup>                                                                                 | 0.7                                                                                          | 2175                                                                         | Comprehensive in one of the hospitals                                                                       | 2012                           | 2013                          |
| Japan                                               | National data                                                                                                          | 0.2                                                                                          | 70 330                                                                       | Comprehensive                                                                                               | 2012                           | 2013                          |
| Kiribati                                            | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Lao People's Democratic Republic                    | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Lao People's Democratic Republic                    | Institute surveillance                                                                                                 | 0                                                                                            | 4                                                                            | Comprehensive (laboratory)                                                                                  | 2011–2012                      | 2013                          |
| Malaysia                                            | National data                                                                                                          | 0.5 (imi),<br>0.7 (mem)                                                                      | 23 333 (imi),<br>22 965 (mem)                                                | Comprehensive                                                                                               | 2012                           | 2013                          |
| Marshall Islands                                    | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Micronesia                                          | National data, incomplete                                                                                              | "Nc"                                                                                         | ≤ 30                                                                         | Comprehensive                                                                                               | 2011                           | 2013                          |
| Mongolia                                            | Publication (99)                                                                                                       | 10.9                                                                                         | 92                                                                           | Community infections                                                                                        | 2011                           | 2013                          |
| Nauru                                               | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| Niue                                                | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| New Zealand                                         | National data                                                                                                          | 0                                                                                            | 366                                                                          | Comprehensive                                                                                               |                                | 2013                          |
| Palau                                               | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| Papua New Guinea                                    | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Philippines                                         | National data                                                                                                          | 3.8                                                                                          | 3696                                                                         | Comprehensive                                                                                               | 2012                           | 2013                          |
| Republic of Korea <sup>a</sup>                      | National data                                                                                                          | 0.39                                                                                         | 7131<br>("Hospitals"<br>+ "Clinics");<br>NI <sup>i</sup> (General hospitals) | Comprehensive                                                                                               | 2011                           | 2013                          |
| Republic of Korea                                   | National network/ institute surveillance                                                                               | 3                                                                                            | 2421                                                                         | Comprehensive                                                                                               | 2012                           | 2013                          |
| Samoa                                               | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Singapore                                           | National data, incomplete <sup>h</sup>                                                                                 |                                                                                              | 73                                                                           | Comprehensive                                                                                               | 2011                           | 2013                          |
| Singapore                                           | Publication (100)                                                                                                      | 0                                                                                            | 198                                                                          | Hospital laboratories                                                                                       | 2006–2007                      | 2008                          |
| Solomon Islands                                     | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Tonga                                               | National data not available                                                                                            |                                                                                              |                                                                              |                                                                                                             |                                | 2013                          |
| Tuvalu                                              | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| Vanuatu                                             | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| Viet Nam <sup>i</sup>                               | No information obtained for this report                                                                                |                                                                                              |                                                                              |                                                                                                             |                                |                               |
| International network                               | ANSORP <sup>i</sup>                                                                                                    | Blood isolates:<br>0.9 (etp);<br>1.4 (imi);<br>Urinary isolates:<br>5.7 (imi);<br>10.2 (etp) | 213 (blood isolates);<br>88 (urinary isolates)                               | Blood isolates, urinary isolates                                                                            | 2012                           | 2013                          |

a. dor, doripenem; etp, ertapenem; imi, imipenem; mem, meropenem

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data were provided, but no formal national data compilation was available.

f. Data from three hospitals aggregated.

g. Information aggregated from more than one surveillance system: «Hospitals»; 0.3%; «Clinics»; 0.3% and "General hospitals" 0.6%.

h. No proportions given. Incidence in hospitals: 0.38 per 10 000 inpatient-days.

i. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

j. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.25 *Staphylococcus aureus*: Resistance to methicillin<sup>a</sup> (MRSA)  
African Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                    | No. tested isolates             | Type of surveillance, population or samples <sup>e</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|-----------------------------------|---------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | Publication (149)                       | 40.5 (Community); 47.4 (Hospital) | 84 (Community); 137 (Hospital)  | <i>S. aureus</i> infections                              | 2006–2007                  | 2011                          |
| Angola                                              | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Benin                                               | National data, incomplete               |                                   |                                 |                                                          |                            | 2013                          |
| Botswana                                            | National data, incomplete               |                                   | 26                              | Invasive isolates                                        | 2012                       | 2013                          |
| Botswana                                            | Publication (150)                       | 23                                | 857                             | Skin and soft tissue infections                          | 2000–2007                  | 2011                          |
| Burkina Faso                                        | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Burundi                                             | National data                           | 13                                | 265                             | Targeted                                                 | 2012                       | 2013                          |
| Cameroon                                            | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Cabo Verde                                          | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Central African Republic                            | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Chad                                                | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Congo                                               | National data                           | Not tested                        | 26                              | Invasive isolates                                        | 2012                       | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Democratic Republic of the Congo                    | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Ethiopia                                            | National data                           | 31.6                              | 175                             | Comprehensive                                            | 2011–2012                  | 2013                          |
| Gabon                                               | Publication (151)                       | 1.6                               | 34                              | Carriage (children with sickle-cell anemia)              | 2009–2010                  | 2013                          |
| Gabon                                               | Publication (152)                       | 3.7                               | 163                             | Infections and carriers                                  | 2008–2010                  | 2011                          |
| Gambia                                              | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Ghana                                               | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Guinea                                              | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Guinea-Bissau                                       | National data                           | 100                               | 31                              | Comprehensive                                            | 2013                       | 2013                          |
| Kenya                                               | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Kenya                                               | Publication (153)                       | 20                                | 207                             | Surgical site infections                                 |                            | 2012                          |
| Lesotho                                             | National data                           | 12                                | 75                              |                                                          | 2012                       | 2013                          |
| Liberia                                             | National data not available             |                                   |                                 |                                                          |                            | 2013                          |
| Madagascar                                          | Publication (3)                         | 13.6                              | 103                             | Hospital acquired infections                             | 2006–2008                  | 2010                          |
| Malawi                                              | National data                           | 0                                 | 13                              | Comprehensive                                            | 2013                       | 2013                          |
| Malawi                                              | Publication (154)                       | 31.3                              | 147                             | Clinical isolates                                        | 2006–2007                  | 2012                          |
| Mali                                                | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Mauritania                                          | National data                           | 80                                | 41                              | Comprehensive                                            | 2013                       | 2013                          |
| Mauritius                                           | National data                           | 51.5                              | 171                             | Hospital isolates                                        | 2012                       | 2013                          |
| Mozambique                                          | No information obtained for this report |                                   |                                 |                                                          |                            |                               |
| Namibia                                             | National data                           | 15                                | 1843                            |                                                          | 2012                       | 2013                          |
| Nigeria                                             | Publication (4)                         | 70                                | 200                             | Blood isolates (children)                                | 2006–2008                  | 2009                          |
| Nigeria                                             | Publication (155)                       | 14                                | 293                             | Intestinal carriage, children                            | 2006                       | 2012                          |
| Nigeria                                             | Publication (104)                       | 60.8                              | 156                             | Healthy carriers                                         | 2011                       | 2012                          |
| Nigeria                                             | Publication (5)                         | 70 (clox)                         | 180                             | Healthy carriers                                         | (2003)–2007                | 2008                          |
| Nigeria                                             | Publication (110)                       | 87.9 (clox)                       | 124                             | Healthy carriers                                         | 2008–2009                  | 2012                          |
| Nigeria                                             | Publication (156)                       | 16.3                              | 98                              | Ear discharge in otitis media                            | 2009–2010                  | 2011                          |
| Nigeria                                             | Publication (157)                       | 88                                | 100                             | Clinical samples (hospitalized patients)                 |                            | 2011                          |
| Nigeria                                             | Publication (158)                       | 100                               | 46                              | Urinary isolates                                         | 2010                       | 2012                          |
| Nigeria                                             | Publication (112)                       | 11 (AIDS pts); 0 (non-AIDS pts)   | 54 (AIDS pts); 0 (non-AIDS pts) | Urinary infections (AIDS and non-AIDS patients)          | 2003–2009                  | 2010                          |
| Nigeria                                             | Publication (104)                       | 60.8                              | 188                             | Healthy carriers                                         | 2011                       | 2012                          |
| Nigeria                                             | Publication (159)                       | 27.5                              | 40                              | Healthy carriers                                         | 2009                       | 2011                          |
| Nigeria                                             | Publication (160)                       | 64.2                              | 150                             | Clinical isolates                                        | 2009                       | 2011                          |
| Nigeria                                             | Publication (161)                       | 33.3                              | 33                              | Blood isolates newborns                                  | 2006–2007                  | 2011                          |
| Nigeria                                             | Publication (162)                       | 64.2                              | 150                             | Clinical isolates                                        | 2009                       | 2011                          |
| Nigeria                                             | Publication (163)                       | 12.5                              | 96                              | Consecutive hospital isolates                            | 2007                       | 2011                          |
| Nigeria                                             | Publication (164)                       | 40                                | 2511                            | Clinical samples                                         | 1987–2000                  | 2011                          |
| Nigeria                                             | Publication (12)                        | 94.8                              | 58                              | Blood isolates (HIV-infected children)                   |                            | 2010                          |
| Rwanda                                              | No information obtained for this report |                                   |                                 |                                                          |                            |                               |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Sao Tome and Principe                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Senegal                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Seychelles                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                |                     |                                                          |                            |                               |
| South Africa                                        | National data                           | 52             | 1177                | Invasive isolates                                        | 2012                       | 2013                          |
| South Sudan                                         | National data not available             |                |                     |                                                          |                            | 2013                          |
| Swaziland                                           | National data                           | 0              | 25                  | Comprehensive                                            | 2013                       | 2013                          |
| Togo                                                | Publication (165)                       | 35.7           | 84                  | Infected dermatology patients                            | 2003–2005                  | 2011                          |
| Uganda                                              | National data, incomplete               |                | 9                   | Comprehensive                                            | 2012                       | 2013                          |
| Uganda                                              | Publication (166)                       | 0              | 54                  | Surgical site infections                                 | 2007                       | 2009                          |
| United Republic of Tanzania                         | National data not available             |                |                     |                                                          |                            | 2013                          |
| United Republic of Tanzania                         | Publication (167)                       | 15             | 160                 | Skin and soft tissue infections                          | 2008                       | 2012                          |
| Zambia                                              | National data                           | 32             | 424                 | Targeted                                                 | 2012                       | 2013                          |
| Zimbabwe                                            | National data not available             |                |                     |                                                          |                            | 2013                          |

a. cef, cefoxitin; clox, cloxacillin; oxa, oxacilin. Data on cefoxitin used when not specified.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

**Table A2.26 *Staphylococcus aureus*: Resistance to methicillin<sup>a</sup> (MRSA)**  
Region of the Americas

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                           | No. tested isolates                    | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|------------------------------------------|----------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Argentina                                           | National data                           | 54                                       | 2177                                   | Community isolates                                       | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Belize                                              | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 49                                       | 1805                                   |                                                          | 2010                       | 2013                          |
| Brazil                                              | National data, incomplete               |                                          | 5                                      |                                                          | 2010                       | 2013                          |
| Brazil                                              | Publication (168)                       | 16                                       | 388                                    | Carriers (health care staff)                             | 2006–2008                  | 2011                          |
| Brazil                                              | Publication (169)                       | 43.4                                     | 53                                     | Blood isolates (dialysis patients)                       |                            | 2010                          |
| Brazil                                              | Publication (170)                       | 2.4                                      | 102                                    | Carriers (students)                                      | 2007                       | 2010                          |
| Brazil                                              | Publication (171)                       | 44.5 (CF patients); 35 (non-CF patients) | 164 (CF patients); 200 non-CF patients | Cystic fibrosis (CF) patients and "non-CF" patients      |                            | 2010                          |
| Brazil                                              | Publication (172)                       | 5.8                                      | 52                                     | Carriers (health care staff)                             | 2007                       | 2008                          |
| Brazil                                              | Publication (173)                       | 31                                       | 2218                                   | Consecutive laboratory isolates                          | 2005–2008                  | 2009                          |
| Brazil                                              | Publication (174)                       | 41.5                                     | 105                                    | Maternity hospital                                       | 2002–2003                  | 2009                          |
| Canada                                              | National data                           | 21                                       | 1052                                   | Sentinel hospitals                                       | 2010                       | 2013                          |
| Chile                                               | National data                           | 90                                       | 135                                    |                                                          | 2010                       | 2013                          |
| Colombia                                            | National data not available             |                                          |                                        |                                                          |                            | 2013                          |
| Colombia                                            | Publication (175)                       | 25                                       | 36                                     | Healthy children                                         | 2008                       | 2010                          |
| Colombia                                            | Publication (176)                       | 7.2                                      | 182                                    | Screening intensive care unit (ICU) patients             | 2007–2008                  | 2010                          |
| Colombia                                            | Publication (177)                       | 60                                       | 39                                     | Children with <i>S. aureus</i> infections                | 2008–2009                  | 2010                          |
| Costa Rica                                          | National data not available             |                                          |                                        |                                                          |                            | 2013                          |
| Costa Rica                                          | Publication (168)                       | 20.9                                     | 296                                    | Health-care workers                                      | 2006                       | 2011                          |
| Cuba                                                | National data                           | 60                                       | 79                                     | Community isolates                                       | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Dominican Republic                                  | National data                           | 30                                       | 1210                                   | Community isolates                                       | 2009                       | 2013                          |
| Ecuador                                             | National data                           | 29                                       | 1111                                   | Community isolates                                       | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 29                                       | 198                                    | Community isolates                                       | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Guatemala                                           | National data                           | 52                                       | 666                                    | Community isolates                                       | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Honduras                                            | National data                           | 30                                       | 975                                    | Community isolates                                       | 2010                       | 2013                          |
| Jamaica                                             | Publication (178)                       | 2.9                                      | 35                                     | Patients with breast abscesses                           |                            | 2012                          |
| Mexico                                              | National data not available             |                                          |                                        |                                                          |                            | 2013                          |
| Mexico                                              | Publication (179)                       | 29.9                                     | 1008                                   | Clinical samples                                         | 2000–2007                  | 2009                          |
| Nicaragua                                           | National data                           | 0                                        | 7                                      | Community isolates                                       | 2010                       | 2013                          |
| Panama                                              | National data                           | 22                                       | 403                                    | Community isolates                                       | 2010                       | 2013                          |
| Panama                                              | National network                        | 21                                       | 3865                                   | Comprehensive                                            | 2012                       | 2013                          |
| Paraguay                                            | National data                           | 27                                       | 264                                    | Community isolates                                       | 2010                       | 2013                          |
| Peru                                                | National data                           | 36                                       | 230                                    | Community isolates                                       | 2010                       | 2013                          |
| Peru                                                | National network                        | 84                                       | 380                                    | Comprehensive                                            | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report |                                          |                                        |                                                          |                            |                               |
| Trinidad and Tobago                                 | Publication (116)                       | 12.5                                     | 32                                     | Hospitalized children                                    | 2007                       | 2010                          |
| United States of America                            | National data                           | 51.3                                     | 12 327                                 | Health-care associated infections                        | 2009–2010                  | 2013                          |
| Uruguay                                             | National data not available             |                                          |                                        |                                                          |                            | 2013                          |
| Uruguay                                             | Publication (180)                       | 40                                       | 1253                                   | Paediatric hospital                                      | (2001)–2006                | 2009                          |
| Uruguay                                             | Publication (181)                       | 76.4                                     | 89                                     | Clinical isolates community (children)                   | 2003–2006                  | 2013                          |
| Venezuela (Bolivarian Republic of)                  | National data                           | 31                                       | 913                                    | Community isolates                                       | 2010                       | 2013                          |

a. cef, cefoxitin; oxa, oxacilin. Data on cefoxitin used when not specified.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.



**Table A2.27 *Staphylococcus aureus*: Resistance to methicillin<sup>a</sup> (MRSA)  
Eastern Mediterranean Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                        | Resistance (%)    | No. tested isolates | Type of surveillance, population or samples <sup>e</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-------------------------------------------------------|-------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report               |                   |                     |                                                          |                            |                               |
| Bahrain                                             | National data                                         | 10                | 109                 |                                                          | 2012                       | 2013                          |
| Djibouti                                            | No information obtained for this report               |                   |                     |                                                          |                            |                               |
| Egypt                                               | National data not available                           |                   |                     |                                                          |                            | 2013                          |
| Egypt                                               | National surveillance (Hospital network) <sup>e</sup> | 46                | 122                 | Health-care associated infections                        | 2002–2010                  | 2013                          |
| Iran (Islamic Republic of)                          | National data                                         | 53                | 2690                | Invasive isolates                                        | 2012                       | 2013                          |
| Iraq                                                | Publication (182)                                     | 46.1              | 657                 | Clinical samples                                         | 2005–2009                  | 2011                          |
| Iraq                                                | Publication (134)                                     | 84                | 79                  | Blood isolates (neonate intensive care unit)             |                            | 2013                          |
| Jordan                                              | National data not available                           |                   |                     |                                                          |                            | 2013                          |
| Kuwait                                              | Publication (183)                                     | 32                | 1846                | 13 hospital (hospitalized patients and outpatients)      | 2005                       | 2008                          |
| Lebanon                                             | National data not available                           |                   |                     |                                                          |                            | 2013                          |
| Lebanon                                             | Publication (32)                                      | 20                | 479                 | Clinical isolates                                        | 2010–2011                  | 2012                          |
| Libya                                               | Publication (184)                                     | 31                | 200                 | Clinical isolates                                        | 2007                       | 2011                          |
| Morocco                                             | National data                                         | 6.2               | 16                  | Hospital isolates                                        | 2012                       | 2013                          |
| Morocco                                             | Publication (185)                                     | 52.9              | 31                  | Intensive care unit                                      | 2002–2005                  | 2008                          |
| Morocco                                             | Publication (186)                                     | 19                | 461                 | Hospital samples                                         | 2006–2008                  | 2009                          |
| Oman                                                | National data                                         | 50                | 751                 | Comprehensive                                            | 2012                       | 2013                          |
| Pakistan                                            | National data, incomplete                             | 12                |                     |                                                          |                            | 2013                          |
| Pakistan                                            | Publication (187)                                     | 28                | 1102                | Clinical isolates                                        | 2006–2008                  | 2011                          |
| Pakistan                                            | Publication (188)                                     | 72.2              | 346                 | Clinical isolates                                        | 2004–2006                  | 2008                          |
| Pakistan                                            | Publication (39)                                      | 38.4              | 52                  | Intensive care unit                                      | 2007                       | 2010                          |
| Pakistan                                            | Publication (47)                                      | 30.7              | 289                 | Vaginal swabs                                            | 2004–2006                  | 2008                          |
| Pakistan                                            | Publication (189)                                     | 1.5               | 85                  | MRSA carriage among health-care workers                  | 2007–2008                  | 2010                          |
| Pakistan                                            | Publication (187)                                     | 38.1              | 1102                | Hospital isolates                                        | 2006–2008                  | 2011                          |
| Pakistan                                            | Publication (190)                                     | 52.6              | 38                  | MRSA carriage among hospital patients                    | 2007                       | 2009                          |
| Qatar                                               | Publication (49)                                      | 13.2              | 53                  | Blood isolates                                           | 2007–2008                  | 2012                          |
| Qatar                                               | Publication (191)                                     | 0.2               | 514                 | Student carriers                                         |                            | 2010                          |
| Saudi Arabia                                        | Publication (192)                                     | 92                | 112                 | Health-care staff                                        | 2007                       | 2010                          |
| Saudi Arabia                                        | Publication (148)                                     | 22.3              | 166                 | Hospital isolates                                        | 2004–2007                  | 2009                          |
| Saudi Arabia                                        | Publication (193)                                     | 39.5              | 186                 | Hospital patients                                        | 2009–2010                  | 2012                          |
| Saudi Arabia                                        | Publication (194)                                     | 0                 | 41                  | Childhood osteomyelitis                                  | 1997–2006                  | 2008                          |
| Saudi Arabia                                        | Publication (195)                                     | 39.4              | 688                 | Clinical isolates                                        | 2008–2009                  | 2011                          |
| Saudi Arabia                                        | Publication (56)                                      | 10.7              | 56                  | Hospital isolates                                        | 2010–2011                  | 2012                          |
| Saudi Arabia                                        | Publication (57)                                      | 65.7              | 67                  | Laboratory records                                       | 2009                       | 2010                          |
| Somalia                                             | No information obtained for this report               |                   |                     |                                                          |                            |                               |
| Sudan                                               | National data not available                           |                   |                     |                                                          |                            | 2013                          |
| Syrian Arab Republic                                | National data not available                           |                   |                     |                                                          |                            | 2013                          |
| Tunisia                                             | Publication (196)                                     | 46.4              | 375                 | Hospital patients                                        | 2005–2006                  | 2008                          |
| Tunisia                                             | Publication (197)                                     | 15.7              | 70                  | Children with osteomyelitis                              | 2007–2009                  | 2012                          |
| Tunisia                                             | Publication (198)                                     | 68.1              | 251                 | Burn patients                                            | 2005–2006                  | 2009                          |
| Tunisia                                             | Publication (199)                                     | 56.3              | 744                 | Burn patients                                            | 2008–2011                  | 2013                          |
| United Arab Emirates                                | National data <sup>f</sup>                            | 27.5              | 3547                | Comprehensive                                            | 2012                       | 2013                          |
| United Arab Emirates                                | Publication (63)                                      | 39.5 <sup>g</sup> | 3434 <sup>g</sup>   | Clinical isolates                                        | (1994 and) 2005            | 2009                          |
| Yemen                                               | Publication (200)                                     | 48.3              | 60                  | Health-care staff                                        |                            | 2011                          |
| International network                               | ANSORP <sup>h</sup>                                   | 64                | 161                 | Blood isolates                                           | 2012                       | 2013                          |

a. cef, cefoxitin; oxa, oxacilin. Data on cefoxitin used when not specified.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. US Naval Medical Research Unit No 3, Global Disease Detection Program, Egypt.

f. Data from United Arab Emirates originate from Abu Dhabi only.

g. Data aggregated from three hospitals.

h. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.28 *Staphylococcus aureus*: Resistance to methicillin<sup>a</sup> (MRSA)**  
European Region

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                       | Resistance (%)                                                                                                                            | No. tested isolates                                                                                        | Type of surveillance, population or samples <sup>e</sup> | Period for data collection             | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------|-------------------------------|
| Albania                                             | National data                                        | 21                                                                                                                                        | 736                                                                                                        | Clinical isolates                                        | 2011–2012                              | 2013                          |
| Andorra                                             | No information obtained for this report              |                                                                                                                                           |                                                                                                            |                                                          |                                        |                               |
| Armenia                                             | National data not available                          |                                                                                                                                           |                                                                                                            |                                                          |                                        | 2013                          |
| Austria                                             | National data                                        | 7.4                                                                                                                                       | 1967                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Azerbaijan                                          | National data not available                          |                                                                                                                                           |                                                                                                            |                                                          |                                        | 2013                          |
| Belarus                                             | No information obtained for this report <sup>e</sup> |                                                                                                                                           |                                                                                                            |                                                          |                                        |                               |
| Belgium                                             | National data                                        | 17.4                                                                                                                                      | 1744                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Bosnia and Herzegovina                              | Publication (136)                                    | 80                                                                                                                                        | 5                                                                                                          | Clinic for gynaecology and obstetrics                    | 2006                                   | 2009                          |
| Bulgaria                                            | National data                                        | 22.4                                                                                                                                      | 214                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Croatia                                             | National data                                        | 13                                                                                                                                        | 702                                                                                                        | Comprehensive                                            | 2012                                   | 2013                          |
| Cyprus                                              | National data                                        | 41.6                                                                                                                                      | 113                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Czech Republic                                      | National data                                        | 14.5                                                                                                                                      | 1554                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Denmark                                             | National data                                        | 1.2                                                                                                                                       | 1452                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Estonia                                             | National data                                        | 1.7                                                                                                                                       | 116                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Finland                                             | National data                                        | 2.8                                                                                                                                       | 1487                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| France                                              | National data                                        | 20.1                                                                                                                                      | 4716                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Georgia                                             | National data not available                          |                                                                                                                                           |                                                                                                            |                                                          |                                        | 2013                          |
| Georgia                                             | Publication (67)                                     | 6/15                                                                                                                                      | 15                                                                                                         | Blood isolates, neonates                                 | 2003–2004                              | 2009                          |
| Germany                                             | National data                                        | 16.2                                                                                                                                      | 2374                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Greece                                              | National data                                        | 39.2                                                                                                                                      | 784                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Hungary                                             | National data                                        | 26.2                                                                                                                                      | 1156                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Iceland                                             | National data                                        | 2.8                                                                                                                                       | 71                                                                                                         | Invasive isolates                                        | 2011                                   | 2013                          |
| Ireland                                             | National data                                        | 23.7                                                                                                                                      | 1057                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Israel                                              | Publication (69)                                     | 48.3                                                                                                                                      | 834 (entire period)                                                                                        | Blood isolates                                           | (1997–)2004                            | 2008                          |
| Israel                                              | Publication (201)                                    | 48.2 (Hospital acquired);<br>42.2 (Health-care associated);<br>27.3 (community);<br>32.3 Hospital;<br>50 (Long-term care facility [LTCF]) | 735 (Hospital acquired);<br>526 (Health-care associated);<br>22 (Community);<br>45 (Hospital);<br>4 (LTCF) | Blood isolates                                           | 1988–1994 and 1999–2007                | 2012                          |
| Israel                                              | Publication (68)                                     | 27.3 (community);<br>32.3 Hospital;<br>50 (Long-term care facility [LTCF])                                                                | 22 (Community);<br>45 (Hospital);<br>4 (LTCF)                                                              | Bacteraemia (community, hospital, LTCF)                  | 2001–2006                              | 2009                          |
| Italy                                               | National data                                        | 38.2                                                                                                                                      | 1261                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Kazakhstan                                          | No information obtained for this report <sup>e</sup> |                                                                                                                                           |                                                                                                            |                                                          |                                        |                               |
| Kyrgyzstan                                          | National data not available                          |                                                                                                                                           |                                                                                                            |                                                          |                                        | 2013                          |
| Latvia                                              | National data                                        | 9.9                                                                                                                                       | 192                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Lithuania                                           | National data                                        | 5.8                                                                                                                                       | 278                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Luxembourg                                          | National data                                        | 20.5                                                                                                                                      | 127                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Malta                                               | National data                                        | 49.2                                                                                                                                      | 130                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Monaco                                              | No information obtained for this report              |                                                                                                                                           |                                                                                                            |                                                          |                                        |                               |
| Montenegro                                          | National data not available                          |                                                                                                                                           |                                                                                                            |                                                          |                                        | 2013                          |
| Netherlands                                         | National data                                        | 1.4                                                                                                                                       | 1801                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Norway                                              | National data                                        | 0.3                                                                                                                                       | 1223                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Poland                                              | National data                                        | 24.3                                                                                                                                      | 860                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Portugal                                            | National data                                        | 54.6                                                                                                                                      | 1307                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Republic of Moldova                                 | National data                                        | 50.3                                                                                                                                      | 2064                                                                                                       |                                                          | 2012                                   | 2013                          |
| Romania                                             | National data                                        | 50.5                                                                                                                                      | 107                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Russian Federation                                  | National data                                        | Hospital isolates: 66.8;<br>Community: 3.8                                                                                                | Hospital: 284;<br>Community: 417                                                                           | Comprehensive (hospital and community, respectively)     | Hospital: 2011–2012<br>Community: 2006 | 2013                          |
| San Marino                                          | No information obtained for this report              |                                                                                                                                           |                                                                                                            |                                                          |                                        |                               |
| Serbia                                              | National data                                        | 44.5                                                                                                                                      | 172                                                                                                        | Invasive isolates                                        | 2012                                   | 2013                          |
| Slovakia                                            | National data                                        | 25.9                                                                                                                                      | 560                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Slovenia                                            | National data                                        | 7.1                                                                                                                                       | 464                                                                                                        | Invasive isolates                                        | 2011                                   | 2013                          |
| Spain                                               | National data                                        | 22.5                                                                                                                                      | 1950                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Sweden                                              | National data                                        | 0.8                                                                                                                                       | 3099                                                                                                       | Invasive isolates                                        | 2011                                   | 2013                          |
| Switzerland                                         | National data                                        | 10.2                                                                                                                                      | 18 527                                                                                                     | Comprehensive                                            | 2012                                   | 2013                          |
| Tajikistan                                          | No information obtained for this report              |                                                                                                                                           |                                                                                                            |                                                          |                                        |                               |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>e</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| The former Yugoslav Republic of Macedonia           | National data                           | 36             | 25                  |                                                          |                            | 2013                          |
| Turkey                                              | National data                           | 31.5           | 887                 | Invasive isolates                                        | 2011                       | 2013                          |
| Turkmenistan                                        | No information obtained for this report |                |                     |                                                          |                            |                               |
| Ukraine                                             | Publication (202)                       | 53.8           | 23 292              | Hospital samples                                         |                            | 2010                          |
| United Kingdom                                      | National data                           | 13.6           | 3408                | Invasive isolates                                        | 2011                       | 2013                          |
| Uzbekistan                                          | No information obtained for this report |                |                     |                                                          |                            |                               |

a. cef, cefoxitin; oxa, oxacilin. Data on cefoxitin used when not specified.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres participate in some RusNet projects.

**Table A2.29 *Staphylococcus aureus*: Resistance to methicillin<sup>a</sup> (MRSA)**  
**South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                    | Resistance (%)                    | No. tested isolates              | Type of surveillance, population or samples <sup>e</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-------------------------------------------------------------------|-----------------------------------|----------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available                                       |                                   |                                  |                                                          |                            | 2013                          |
| Bangladesh                                          | Publication (73)                                                  | 46                                | 103                              | Clinical isolates                                        | 2011–2012                  | 2013                          |
| Bhutan                                              | National data                                                     | 10                                | 130                              | Comprehensive                                            | 2011–2012                  | 2013                          |
| Democratic peoples republic of Korea                | No information obtained for this report                           |                                   |                                  |                                                          |                            |                               |
| India                                               | National data not available                                       |                                   |                                  |                                                          |                            | 2013                          |
| India                                               | Publication (140)                                                 | 37                                | 38                               | Blood isolates (children)                                | (1994)–2002–2003           | 2008                          |
| India                                               | Publication (97)                                                  | 40                                | 38                               | Burn unit                                                |                            | 2011                          |
| India                                               | Publication (203)                                                 | 5.5                               | 109                              | Dental outpatient clinic                                 | 2011–2012                  | 2012                          |
| India                                               | Publication (204)                                                 | 4.2                               | 96                               | Carriage (urban community)                               |                            | 2009                          |
| India                                               | Publication (205)                                                 | 80.4 (Community); 80.6 (Hospital) | 485 (Community); 1022 (Hospital) | Community and hospital isolates                          | 2009–2012                  | 2013                          |
| India                                               | Publication (206)                                                 | 43                                | 100                              | Burn unit                                                | 2010                       | 2012                          |
| India                                               | Publication (207)                                                 | 41                                | 26 310                           | Hospital patients (in- and out patients)                 | 2008–2009                  | 2013                          |
| India                                               | Publication (208)                                                 | 55                                | 74                               | Community-acquired bone/joint infections                 | 2004–2008                  | 2013                          |
| India                                               | Publication (209)                                                 | 20.8                              | 284                              | Hospital                                                 |                            | 2012                          |
| India                                               | Publication (210)                                                 | 63                                | 38                               | Hospital (orthopaedic surgical unit)                     | 2007–2009                  | 2013                          |
| India                                               | Publication (211)                                                 | 19                                | 63                               | Carriage (community)                                     |                            | 2009                          |
| India                                               | Publication (212)                                                 | 11.4                              | 70                               | Carriage (health-care workers)                           | 2009–2010                  | 2013                          |
| India                                               | Publication (91)                                                  | 30                                | 221                              | Clinical samples                                         | 2007–2009                  | 2012                          |
| India                                               | Publication (213)                                                 | 11.1                              | 43                               | Neonatal septicemia isolates                             | 2003–2007                  | 2010                          |
| India                                               | Publication (214)                                                 | 54                                | 70                               | Hospital                                                 |                            | 2012                          |
| Indonesia                                           | National data not available <sup>e</sup>                          |                                   |                                  |                                                          |                            | 2013                          |
| Maldives                                            | No information obtained for this report                           |                                   |                                  |                                                          |                            |                               |
| Myanmar                                             | National data                                                     | 26                                | 2650                             | Comprehensive                                            | 2012                       | 2013                          |
| Nepal                                               | National data not available                                       |                                   |                                  |                                                          |                            | 2013                          |
| Nepal                                               | Publication (215)                                                 | 68                                | 600                              | Skin and soft tissue infections                          | 68                         | 2010                          |
| Nepal                                               | Publication (216)                                                 | 63                                | 38                               | Orthopaedic surgery                                      | 2001–2009                  | 2010                          |
| Nepal                                               | Publication (217)                                                 | 26.1                              | 750                              | Clinical isolates                                        | 2003–2004                  | 2008                          |
| Nepal                                               | Publication (218)                                                 | 69.1                              | 162                              | Clinical isolates                                        | 2005–2007                  | 2009                          |
| Nepal                                               | Publication (219)                                                 | 56.1                              | 57                               | Carriers (children <15)                                  | 2007                       | 2008                          |
| Nepal                                               | Publication (220)                                                 | 31.1                              | 264                              | Clinical isolates                                        |                            | 2010                          |
| Nepal                                               | Publication (221)                                                 | 45                                | 149                              | Clinical isolates (hospital infections)                  | 2007–2008                  | 2009                          |
| Nepal                                               | Publication (222)                                                 | 2.3                               | 35                               | Carriers (hospital staff)                                | 2008                       | 2009                          |
| Sri Lanka                                           | National data not available                                       |                                   |                                  |                                                          |                            | 2013                          |
| Sri Lanka                                           | Publication (223)                                                 | 13.6                              | 59                               | Carriers (patients with atopic dermatitis)               |                            | 2010                          |
| Thailand                                            | National data                                                     | 21.6 (cef); 24.2 (oxa)            | 14 722 (cef); 6574 (oxa)         | Comprehensive                                            | 2012                       | 2013                          |
| Timor-Leste                                         | Naitional data, incomplete, from national laboratory <sup>f</sup> | 25                                |                                  |                                                          | 2010–2012                  | 2013                          |
| International network                               | ANSORP <sup>g</sup>                                               | 64                                | 161                              | Blood isolates                                           | 2012                       | 2013                          |

a. cef, cefoxitin; oxa, oxacilin. Data on cefoxitin used when not specified.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

f. Data were provided, but no formal national data compilation was available.

g. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.30 *Staphylococcus aureus*: Resistance to methicillin<sup>a</sup> (MRSA)**  
**Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                                                                                      | Resistance (%)                              | No. tested isolates                                                     | Type of surveillance, population or samples <sup>c</sup>    | Period for data collection | Year of publication or report |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------|-------------------------------|
| Australia                                           | National data                                                                                                       | 30                                          | 703                                                                     | Comprehensive                                               | 2011                       | 2013                          |
| Brunei Darussalam                                   | National data from hospital laboratory                                                                              | 8.2                                         | 911                                                                     | Comprehensive                                               | 2012                       | 2013                          |
| Cambodia                                            | National data not available                                                                                         |                                             |                                                                         |                                                             |                            | 2013                          |
| Cambodia                                            | National data <sup>e</sup> collected from several sources by public health institute (NIPH). Pasteur Institute (PI) | 55.6 (NIPH); 37.8 (PI)                      | 36 (NIPH); 45 (PI)                                                      | Blood, sputum, and wound (NIPH); Laboratory data (PI)       | 2013                       | 2013                          |
| China                                               | National data                                                                                                       | 37.1 (oxa), 41.1 (cef)                      | 57 294 (oxa), 25 636 (cef)                                              | Comprehensive                                               | 2012                       | 2013                          |
| Cook Islands                                        | No information obtained for this report                                                                             |                                             |                                                                         |                                                             |                            |                               |
| Fiji                                                | National data not available                                                                                         |                                             |                                                                         |                                                             |                            | 2013                          |
| Fiji                                                | Institute surveillance <sup>e, f</sup>                                                                              | 2.4                                         | 2502                                                                    | Comprehensive (2 hospitals); NI <sup>g</sup> (one hospital) | 2012                       | 2013                          |
| Japan                                               | National data                                                                                                       | 53                                          | 221 239                                                                 | Comprehensive                                               | 2012                       | 2013                          |
| Kiribati                                            | National data                                                                                                       | 31                                          | 36                                                                      | Comprehensive                                               | 2012                       | 2013                          |
| Lao People's Democratic Republic                    | National data                                                                                                       | 8.8                                         | 34                                                                      |                                                             | 2012–2013                  | 2013                          |
| Lao People's Democratic Republic                    | Institute surveillance                                                                                              | 21.6                                        | 37                                                                      | Comprehensive (laboratory)                                  | 2011–2012                  | 2013                          |
| Malaysia                                            | National data                                                                                                       | 17.3                                        | 30 766                                                                  | Comprehensive                                               | 2012                       | 2013                          |
| Marshall Islands                                    | National data, incomplete                                                                                           |                                             |                                                                         |                                                             | 2011–2012                  | 2013                          |
| Micronesia                                          | National data                                                                                                       | 4                                           | 113                                                                     | Comprehensive                                               | 2011                       | 2013                          |
| Mongolia                                            | Publication (99)                                                                                                    | 60.1                                        | 92                                                                      | Community-acquired infections                               | 2011                       | 2013                          |
| Nauru                                               | No information obtained for this report                                                                             |                                             |                                                                         |                                                             |                            | 2013                          |
| New Zealand                                         | National data                                                                                                       | 10.4                                        | 108 786                                                                 | Comprehensive                                               | 2011                       | 2013                          |
| Niue                                                | No information obtained for this report                                                                             |                                             |                                                                         |                                                             |                            |                               |
| Palau                                               | No information obtained for this report                                                                             |                                             |                                                                         |                                                             |                            |                               |
| Papua New Guinea                                    | National data <sup>h</sup>                                                                                          | 43.9                                        | 164                                                                     | Blood, urine, wounds                                        | 2012                       | 2013                          |
| Philippines                                         | National data                                                                                                       | 54.9                                        | 1958                                                                    | Comprehensive                                               | 2012                       | 2013                          |
| Republic of Korea*                                  | National data                                                                                                       | 57.7; <sup>i</sup> 70.6 "General hospitals" | 12 579 ("Hospitals" + "Clinics"); NI <sup>g</sup> ("General hospitals") | Comprehensive                                               | (2007)–2011                | 2013                          |
| Republic of Korea                                   | National network/ institute surveillance                                                                            | 73                                          | 3673                                                                    | Comprehensive (hospital samples)                            | 2012                       | 2013                          |
| Samoa                                               | National data                                                                                                       | 24                                          | 389                                                                     | Comprehensive                                               | 2011                       | 2013                          |
| Singapore                                           | National data, incomplete <sup>j</sup>                                                                              |                                             | 3409                                                                    | (i) Comprehensive and (ii) Bacteraemia, respectively        | 2011                       | 2013                          |
| Singapore                                           | Publication (224)                                                                                                   | 82                                          | 28                                                                      | Cirrhotic patients                                          | 2007–2008                  | 2011                          |
| Solomon Islands                                     | National data, incomplete                                                                                           |                                             | 50                                                                      |                                                             | 2012                       | 2013                          |
| Tonga                                               | National data                                                                                                       | 17.2                                        | 430                                                                     |                                                             | 2012                       | 2013                          |
| Tuvalu                                              | No information obtained for this report                                                                             |                                             |                                                                         |                                                             |                            | 2013                          |
| Vanuatu                                             | No information obtained for this report                                                                             |                                             |                                                                         |                                                             |                            | 2013                          |
| Viet Nam                                            | No information obtained for this report <sup>k</sup>                                                                |                                             |                                                                         |                                                             |                            |                               |
| International network                               | ANSORP <sup>l</sup>                                                                                                 | 64                                          | 161                                                                     | Blood isolates                                              | 2012                       | 2013                          |

a. cef, cefoxitin; oxa, oxacilin. Data on cefoxitin used when not specified.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data were provided, but no formal national data compilation was available.

f. Data from three hospitals aggregated.

g. NI – No information obtained, or incomplete.

h. National data from different types of samples (blood, urinary and wounds) aggregated.

i. Data aggregated from two surveillance systems «Hospitals» and «Clinics».

j. No proportions obtained. Incidence in hospitals: (i) 16.3 per 10,000 inpatient-days (ii) 1.0 per 10,000 inpatient-days.

k. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

l. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.31** *Streptococcus pneumoniae*: Resistance, or non-susceptibility, to penicillin  
African Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                     | Not specified whether resistant or non-susceptible (%) | Resistant (%)                | Non-susceptible (%) | No. tested isolates           | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------|------------------------------|---------------------|-------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | Publication (225)                                  |                                                        | 23.5 (Meningitis); 1 (Other) |                     | 111 (Meningitis); 183 (Other) |                                                          | 2001–2010                  | 2012                          |
| Algeria                                             | National data from international publication (226) |                                                        |                              | 44                  | 71                            | Invasive isolates                                        | (2003)–2005                | 2009                          |
| Angola                                              | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Benin                                               | National data, incomplete                          |                                                        |                              |                     |                               |                                                          |                            | 2013                          |
| Botswana                                            | National data not available                        |                                                        |                              |                     |                               |                                                          |                            | 2013                          |
| Botswana                                            | Publication (227)                                  |                                                        | 36                           |                     | 125                           | Patients with meningitis                                 | 2000–2008                  | 2011                          |
| Burkina Faso                                        | National data not available                        |                                                        |                              |                     |                               |                                                          |                            |                               |
| Burkina Faso                                        | Publication (228)                                  |                                                        | 3.8                          |                     | 235                           | Infected children                                        | 2000–2001                  | 2009                          |
| Burundi                                             | National data                                      | 20                                                     |                              |                     | 5                             |                                                          | 2012                       | 2013                          |
| Cameroon                                            | Publication (229)                                  |                                                        | 100                          |                     | 30                            | Upper respiratory tract (children)                       | 2004–2005                  | 2012                          |
| Cabo Verde                                          | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Central African Republic                            | National data                                      | 50                                                     |                              |                     | 4                             |                                                          | 2012                       | 2013                          |
| Central African Republic                            | Publication (230)                                  | 6                                                      |                              |                     | 62                            | Paediatric patients                                      | 2004–2005                  | 2008                          |
| Chad                                                | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Congo                                               | National data not available                        |                                                        |                              |                     |                               |                                                          |                            | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Democratic Republic of the Congo                    | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report            |                                                        |                              |                     |                               |                                                          |                            |                               |
| Ethiopia                                            | National data                                      | 14                                                     |                              |                     | 8                             | Comprehensive                                            | 2011–2012                  | 2013                          |
| Ethiopia                                            | Publication (231)                                  |                                                        |                              | 69                  | 49                            | Hospital patients                                        | 2001–2005                  | 2008                          |
| Gabon                                               | Publication (151)                                  |                                                        |                              | 9                   | 30                            | Carriage (children with sickle-cell anemia)              |                            | 2013                          |
| Gambia                                              | National data not available                        |                                                        |                              |                     |                               |                                                          |                            | 2013                          |
| Ghana                                               | National data                                      | 58.1                                                   |                              |                     | 50                            | Comprehensive                                            | 2013                       | 2013                          |
| Guinea                                              | National data not available                        |                                                        |                              |                     |                               |                                                          |                            | 2013                          |
| Guinea-Bissau                                       | National data                                      | 33.3                                                   |                              |                     | 3                             | Comprehensive                                            |                            | 2013                          |
| Kenya                                               | National data not available                        |                                                        |                              |                     |                               |                                                          |                            | 2013                          |
| Kenya                                               | Publication (232)                                  | 24                                                     |                              |                     | 33                            | Invasive infections in neonates and infants              | 2001–2009                  | 2010                          |
| Lesotho                                             | National data                                      | 0                                                      |                              |                     | 4                             |                                                          | 2012                       | 2013                          |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Not specified whether resistant or non-susceptible (%) | Resistant (%)                           | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|--------------------------------------------------------|-----------------------------------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Liberia                                             | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| Madagascar                                          | No information obtained for this report |                                                        |                                         |                     |                     |                                                          |                            |                               |
| Malawi                                              | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| Malawi                                              | Publication (233)                       |                                                        | 9–18 (during study period) <sup>d</sup> |                     | 4445                | Invasive isolates                                        | 2000–2009                  | 2011                          |
| Mali                                                | No information obtained for this report |                                                        |                                         |                     |                     |                                                          |                            |                               |
| Mauritania                                          | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| Mauritius                                           | National data                           | 60                                                     |                                         |                     | 45                  | Comprehensive                                            | 2012                       | 2013                          |
| Mozambique                                          | Publication (234)                       |                                                        |                                         | 11                  | 326                 | Meningitis in children                                   | 2001–2006                  | 2010                          |
| Namibia                                             | National data                           | 57                                                     |                                         |                     | 150                 |                                                          | 2012                       | 2013                          |
| Niger                                               | National data not available             |                                                        |                                         |                     |                     |                                                          |                            |                               |
| Nigeria                                             | Publication (235)                       |                                                        |                                         | 29.7                | 37                  | Carriers (children)                                      |                            | 2009                          |
| Rwanda                                              | No information obtained for this report |                                                        |                                         |                     |                     |                                                          |                            |                               |
| Sao Tome and Principe                               | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| Senegal                                             | Publication (236)                       | 33.3                                                   |                                         |                     | 105                 | Respiratory samples                                      | 2007–2008                  | 2009                          |
| Seychelles                                          | No information obtained for this report |                                                        |                                         |                     |                     |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                                                        |                                         |                     |                     |                                                          |                            |                               |
| South Africa                                        | National data                           | 3                                                      |                                         |                     | 129                 | Invasive isolates                                        | 2012                       | 2013                          |
| South Sudan                                         | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| Swaziland                                           | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| Togo                                                | No information obtained for this report |                                                        |                                         |                     |                     |                                                          |                            |                               |
| Uganda                                              | National data                           | 24                                                     |                                         |                     | 4                   | Comprehensive                                            | 2012                       | 2013                          |
| Uganda                                              | Publication (237)                       | 79                                                     |                                         |                     | 38                  | Invasive isolates                                        | 2006–2007                  | 2009                          |
| Uganda                                              | Publication (238)                       | 32                                                     |                                         |                     | 68                  | Invasive (HIV patients)                                  | 1996–2007                  | 2010                          |
| United Republic of Tanzania                         | National data not available             |                                                        |                                         |                     |                     |                                                          |                            | 2013                          |
| United Republic of Tanzania                         | Publication (239)                       | 67.8                                                   |                                         |                     | 115                 | Carriers (children)                                      |                            | 2012                          |
| Zambia                                              | National data                           | 16.2                                                   |                                         |                     | 37                  |                                                          | 2012                       | 2013                          |
| Zimbabwe                                            | National data                           | 20                                                     |                                         |                     | 5                   | Targeted                                                 | 2012                       | 2013                          |
| International <sup>e</sup>                          | Publication (240)                       |                                                        |                                         | 47                  | 236                 | Clinical isolates                                        | 2006–2007                  | 2009                          |
| International                                       | Publication (241)                       | 0                                                      |                                         |                     | 442                 | Invasive isolates                                        | 2003–2007                  | 2009                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. No further details on denominator given.

e. Kenya, Uganda, United Republic of Tanzania and Ethiopia.



**Table A2.32** *Streptococcus pneumoniae*: Resistance, or non-susceptibility, to penicillin  
Region of the Americas

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%)                  | No. tested isolates                  | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|--------------------------------------------------------|---------------|--------------------------------------|--------------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Argentina                                           | National data                           | 27.5                                                   |               |                                      | 754                                  | Invasive isolates                                        | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Belize                                              | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 65                                                     |               |                                      | 11                                   | Invasive isolates                                        | 2010                       | 2013                          |
| Brazil                                              | National data                           | 20.1                                                   |               |                                      | 807                                  | Invasive isolates                                        | 2010                       | 2013                          |
| Canada                                              | National data                           | 4.3                                                    |               |                                      | 185                                  | Sentinel hospitals                                       | 2011                       | 2013                          |
| Chile                                               | National data                           | 42.1                                                   |               |                                      | 815                                  | Invasive isolates                                        | 2010                       | 2013                          |
| Colombia                                            | National data                           | 34.5                                                   |               |                                      | 369                                  | Invasive isolates                                        | 2010                       | 2013                          |
| Costa Rica                                          | National data                           | 24.9                                                   |               |                                      | 64                                   | Invasive isolates                                        | 2010                       | 2013                          |
| Cuba                                                | National data                           | 28.6                                                   |               |                                      | 63                                   | Invasive isolates                                        | 2010                       | 2013                          |
| Dominica                                            | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Dominican Republic                                  | National data                           | 46.5                                                   |               |                                      | 43                                   | Invasive isolates                                        | 2010                       | 2013                          |
| Ecuador                                             | National data                           | 4.4                                                    |               |                                      | 44                                   | Invasive isolates                                        | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 29.8                                                   |               |                                      | 47                                   | Invasive isolates                                        | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Guatemala                                           | National data                           | 33                                                     |               |                                      | 8                                    | Invasive isolates                                        | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Honduras                                            | National data                           | 66                                                     |               |                                      | 3                                    | Community isolates                                       | 2010                       | 2013                          |
| Jamaica                                             | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Mexico                                              | National data                           | 57.8                                                   |               |                                      | 19                                   | Community isolates                                       | 2010                       | 2013                          |
| Mexico                                              | Publication (242)                       |                                                        |               | 64 (Meningitis); 53 (Non-meningitis) | 58 (Meningitis); 47 (Non-meningitis) | Invasive infections                                      | 2000–2005                  | 2008                          |
| Nicaragua                                           | National data                           | 0.4                                                    |               |                                      | 12                                   | Community isolates                                       | 2010                       | 2013                          |
| Panama                                              | National data                           | 0                                                      |               |                                      | 63                                   | Invasive isolates                                        | 2010                       | 2013                          |
| Panama                                              | National network                        | 11                                                     |               |                                      | 140                                  | Comprehensive                                            | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                           | 47.7                                                   |               |                                      | 109                                  | Invasive isolates                                        | 2010                       | 2013                          |
| Peru                                                | National data                           | 58.8                                                   |               |                                      | 17                                   | Community isolates                                       | 2010                       | 2013                          |
| Peru                                                | National network                        | 47                                                     |               |                                      | 17                                   | Comprehensive                                            | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                                                        |               |                                      |                                      |                                                          |                            |                               |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|--------------------------------------------------------|---------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Saint Vincent and the Grenadines                    | No information obtained for this report |                                                        |               |                     |                     |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report |                                                        |               |                     |                     |                                                          |                            |                               |
| Trinidad and Tobago                                 | No information obtained for this report |                                                        |               |                     |                     |                                                          |                            |                               |
| United States of America                            | National data                           | 4.2                                                    |               |                     | 3197                | Invasive isolates                                        | 2011                       | 2013                          |
| Uruguay                                             | National data                           | 1.1                                                    |               |                     | 176                 | Invasive isolates                                        | 2010                       | 2013                          |
| Venezuela (Bolivarian Republic of)                  | National data                           |                                                        |               | 0                   | 145                 | Invasive isolates                                        | 2010                       | 2013                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

**Table A2.33** *Streptococcus pneumoniae*: Resistance, or non-susceptibility, to penicillin  
Eastern Mediterranean Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                     | Not specified whether resistant or non-susceptible (%) | Resistant (%)                  | Non-susceptible (%) | No. tested isolates          | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------|--------------------------------|---------------------|------------------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report            |                                                        |                                |                     |                              |                                                          |                            |                               |
| Bahrain                                             | National data not available                        |                                                        |                                |                     |                              |                                                          |                            | 2013                          |
| Djibouti                                            | No information obtained for this report            |                                                        |                                |                     |                              |                                                          |                            |                               |
| Egypt                                               | National data not available                        |                                                        |                                |                     |                              |                                                          |                            | 2013                          |
| Egypt                                               | National data from international publication (226) |                                                        |                                | 17                  | 123                          | Invasive isolates                                        | 2003–2005                  | 2009                          |
| Iran (Islamic Republic of)                          | National data                                      | 33.9                                                   |                                |                     | 115                          | Invasive                                                 | 2007                       | 2013                          |
| Iraq                                                | No information obtained for this report            |                                                        |                                |                     |                              |                                                          |                            |                               |
| Jordan                                              | National data not available                        |                                                        |                                |                     |                              |                                                          |                            | 2013                          |
| Jordan                                              | National data from international publication (226) |                                                        |                                | 46                  | 57                           | Invasive isolates                                        | 2003–2005                  | 2009                          |
| Kuwait                                              | Publication (243)                                  | 56                                                     |                                |                     | 1353                         | Hospital patients                                        | 1997–2007                  | 2010                          |
| Kuwait                                              | Publication (244)                                  |                                                        | 15.4 (Meningitis); 0.3 (Other) |                     | 13 (Meningitis); 382 (Other) | Clinical isolates                                        | 2006–2011                  | 2012                          |
| Kuwait                                              | Publication (245)                                  |                                                        | 64                             |                     | 397                          | Consecutive clinical isolates                            | 2004–2005                  | 2008                          |
| Lebanon                                             | National data not available                        |                                                        |                                |                     |                              |                                                          |                            | 2013                          |
| Lebanon                                             | Publication (246)                                  |                                                        |                                | 17.4                | 257                          | Invasive isolates                                        |                            | 2012                          |
| Libya                                               | No information obtained for this report            |                                                        |                                |                     |                              |                                                          |                            |                               |
| Morocco                                             | National data                                      | 25                                                     |                                |                     | 3                            | Sentinel sites                                           | 2013                       | 2013                          |
| Morocco                                             | Publication (247)                                  |                                                        |                                | 34.7                | 302                          | Carriers, children                                       | 2008–2009                  | 2011                          |
| Morocco                                             | Publication (248)                                  |                                                        |                                | 24.8                | 955                          | Comprehensive                                            | 1998–2008                  | 2012                          |
| Morocco                                             | National data from international publication (226) |                                                        |                                | 17                  | 42                           | Invasive isolates                                        | 2003–2005                  | 2009                          |
| Oman                                                | National data                                      |                                                        |                                | 5                   | 131                          | Comprehensive                                            | 2012                       | 2013                          |
| Pakistan                                            | National data, incomplete                          |                                                        | 14.0                           |                     |                              | Targeted                                                 |                            | 2013                          |
| Pakistan                                            | Publication (249)                                  |                                                        | 3                              |                     | 100                          | Community-acquired infections                            | 2006                       | 2008                          |
| Pakistan                                            | Publication (250)                                  |                                                        |                                | 41                  | 37                           | Children                                                 | 2009–2010                  | 2011                          |
| Qatar                                               | No information obtained for this report            |                                                        |                                |                     |                              |                                                          |                            |                               |
| Saudi Arabia                                        | Publication (251)                                  |                                                        | 2.4                            | 48.5                | 41                           | Invasive                                                 | 2001–2007                  | 2009                          |
| Saudi Arabia                                        | Publication (252)                                  |                                                        | 13.9                           | 40.7                | 311                          | Invasive (children)                                      | 2005–2010                  | 2012                          |
| Somalia                                             | No information obtained for this report            |                                                        |                                |                     |                              |                                                          |                            |                               |
| Sudan                                               | National data not available                        |                                                        |                                |                     |                              |                                                          |                            | 2013                          |
| Syrian Arab Republic                                | National data not available                        |                                                        |                                |                     |                              |                                                          |                            | 2013                          |
| Tunisia                                             | Publication (225)                                  | 0                                                      |                                |                     | 34                           | Severe pneumonia                                         | 1999–2008                  | 2012                          |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                     | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------|---------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Tunisia                                             | Publication (253)                                  | 52.8                                                   |               |                     | 210                 | Children                                                 | 1998–2004                  | 2009                          |
| Tunisia                                             | National data from international publication (226) |                                                        |               | 27                  | 33                  | Invasive isolates                                        | (2003)–2005                | 2009                          |
| United Arab Emirates <sup>d</sup>                   | National data                                      |                                                        | 12.9          |                     | 139                 | Comprehensive                                            | 2012                       | 2013                          |
| Yemen                                               | Publication (254)                                  | 93.3                                                   |               |                     | 32                  | Carriers, children                                       | 2006                       | 2008                          |
| International network <sup>e</sup>                  | ANSORP                                             |                                                        |               | 4.6                 | 2144                | Non-meningitis infections                                | 2008–2009                  | 2012                          |
| International                                       | Publication (240)                                  |                                                        |               | 47                  | 236                 | Clinical isolates                                        | 2006–2008                  | 2009                          |
| International                                       | Publication (255)                                  |                                                        |               | 65                  | 702                 | Invasive                                                 | 1990–2007                  | 2009                          |
| International                                       | Publication (226)                                  |                                                        |               | 26                  | 1298                | Invasive isolates                                        | 2003–2005                  | 2009                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Data from United Arab Emirates originate from Abu Dhabi only.

e. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.34** *Streptococcus pneumoniae*: Resistance, or non-susceptibility, to penicillin  
European Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                       | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|--------------------------------------------------------|---------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Albania                                             | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Andorra                                             | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| Armenia                                             | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Austria                                             | National data                                        |                                                        | 1.7           | 2.9                 | 405                 | Invasive isolates                                        | 2011                       | 2013                          |
| Azerbaijan                                          | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Belarus                                             | No information obtained for this report <sup>d</sup> |                                                        |               |                     |                     |                                                          |                            |                               |
| Belgium                                             | National data                                        |                                                        | 0.8           | 0.9                 | 1829                | Invasive isolates                                        | 2011                       | 2013                          |
| Bosnia and Herzegovina                              | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| Bulgaria                                            | National data                                        |                                                        | 21.2          | 21.2                | 33                  | Invasive isolates                                        | 2011                       | 2013                          |
| Croatia                                             | National data                                        |                                                        |               | 30                  | 2950                | Comprehensive                                            | 2012                       | 2013                          |
| Cyprus                                              | National data                                        |                                                        | 25            | 25                  | 12                  | Invasive isolates                                        | 2011                       | 2013                          |
| Cyprus                                              | National data from international publication (226)   |                                                        |               | 15                  | 26                  | Invasive isolates                                        | 2003–2005                  | 2009                          |
| Czech Republic                                      | National data                                        |                                                        | 0             | 3.8                 | 316                 | Invasive isolates                                        | 2011                       | 2013                          |
| Denmark                                             | National data                                        |                                                        | 0.2           | 4.8                 | 896                 | Invasive isolates                                        | 2011                       | 2013                          |
| Estonia                                             | National data                                        |                                                        | 2             | 2                   | 51                  | Invasive isolates                                        | 2011                       | 2013                          |
| Finland                                             | National data                                        |                                                        | 0.9           | 27.7                | 754                 | Invasive isolates                                        | 2012                       | 2013                          |
| France                                              | National data                                        |                                                        | 0.1           |                     | 23.8                | Invasive isolates                                        | 2011                       | 2013                          |
| Georgia                                             | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Germany                                             | National data                                        |                                                        | 0.3           | 1.7                 | 347                 | Invasive isolates                                        | 2011                       | 2013                          |
| Greece                                              | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Hungary                                             | National data                                        |                                                        | 5.8           | 11.6                | 139                 | Invasive isolates                                        | 2011                       | 2013                          |
| Iceland                                             | National data                                        |                                                        | 6.3           | 9.4                 | 32                  | Invasive isolates                                        | 2011                       | 2013                          |
| Ireland                                             | National data                                        |                                                        | 6.2           | 19.5                | 324                 | Invasive isolates                                        | 2011                       | 2013                          |
| Israel                                              | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| Italy                                               | National data                                        |                                                        | 6.3           | 6.9                 | 174                 | Invasive isolates                                        | 2011                       | 2013                          |
| Kazakhstan                                          | No information obtained for this report <sup>d</sup> |                                                        |               |                     |                     |                                                          |                            |                               |
| Kyrgyzstan                                          | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Latvia                                              | National data                                        |                                                        | 10.0          | 12.5                | 40                  | Invasive isolates                                        | 2011                       | 2013                          |
| Lithuania                                           | National data                                        |                                                        | 2.1           | 18.8                | 48                  | Invasive isolates                                        | 2011                       | 2013                          |
| Luxembourg                                          | National data                                        |                                                        | 2             | 8                   | 50                  | Invasive isolates                                        | 2011                       | 2013                          |
| Malta                                               | National data                                        |                                                        | 10            | 50                  | 10                  | Invasive isolates                                        | 2011                       | 2013                          |
| Malta                                               | National data from international publication (226)   |                                                        |               | 13                  | 40                  | Invasive isolates                                        | 2003–2005                  | 2009                          |
| Monaco                                              | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| Montenegro                                          | National data not available                          |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Netherlands                                         | National data                                        |                                                        | 0.3           | 1.1                 | 1067                | Invasive isolates                                        | 2011                       | 2013                          |
| Norway                                              | National data                                        |                                                        | 0.0           | 3.4                 | 619                 | Invasive isolates                                        | 2011                       | 2013                          |
| Poland                                              | National data                                        |                                                        | 4.2           | 18.1                | 165                 | Invasive isolates                                        | 2011                       | 2013                          |
| Portugal                                            | National data                                        |                                                        | 8.4           | 10.5                | 439                 | Invasive isolates                                        | 2011                       | 2013                          |
| Republic of Moldova                                 | National data                                        |                                                        |               | 72.7                | 1361                |                                                          | 2012                       | 2013                          |
| Romania                                             | National data                                        |                                                        | 61.1          | 61.1                | 36                  | Invasive isolates                                        | 2011                       | 2013                          |
| Russian Federation                                  | National data                                        |                                                        | 0.6           | 10.8                | 788                 |                                                          | 2008–2009                  | 2013                          |
| San Marino                                          | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                       | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|--------------------------------------------------------|---------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Serbia                                              | National data                                        | 32.3                                                   |               |                     | 31                  | Invasive isolates                                        | 2012                       | 2013                          |
| Slovakia                                            | National data                                        |                                                        | 3.8           | 7.6                 | 26                  | Invasive isolates                                        | 2011                       | 2013                          |
| Slovenia                                            | National data                                        |                                                        | 0.8           | 12.3                | 252                 | Invasive isolates                                        | 2011                       | 2013                          |
| Spain                                               | National data                                        |                                                        | 9.8           | 30.2                | 736                 | Invasive isolates                                        | 2011                       | 2013                          |
| Sweden                                              | National data                                        |                                                        | 3.2           | 3.5                 | 1013                | Invasive isolates                                        | 2011                       | 2013                          |
| Switzerland                                         | National data                                        |                                                        | 3.1           |                     | 1713                | Comprehensive                                            | 2012                       | 2013                          |
| Tajikistan                                          | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| The former Yugoslav Republic of Macedonia           | National data                                        | 0                                                      |               |                     | 3                   | Invasive isolates                                        | Invasive isolates          | 2013                          |
| Turkey                                              | National data                                        | 44.8                                                   |               |                     | 58                  | Meningitis                                               | 2011                       | 2013                          |
| Turkmenistan                                        | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| Ukraine                                             | No information obtained for this report <sup>d</sup> |                                                        |               |                     |                     |                                                          |                            |                               |
| United Kingdom                                      | National data                                        |                                                        | 0.8           | 5.5                 | 1324                | Invasive isolates                                        | 2011                       | 2013                          |
| Uzbekistan                                          | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Some centres participate in some RusNet projects.

**Table A2.35** *Streptococcus pneumoniae*: Resistance, or non-susceptibility, to penicillin  
South East Asian Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                                   | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------|---------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available                                      |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Bangladesh                                          | Publication (256)                                                |                                                        | 0             |                     | 139                 | Invasive isolates                                        | 2004–2007                  | 2009                          |
| Bhutan                                              | National data                                                    | 0                                                      |               |                     | 13                  | Comprehensive                                            | 2012                       | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report                          |                                                        |               |                     |                     |                                                          |                            |                               |
| India                                               | National data not available                                      |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| India                                               | Publication (257)                                                |                                                        | 5.6           |                     | 776                 | Carriers                                                 | 2004                       | 2013                          |
| Indonesia                                           | National data not available <sup>d</sup>                         |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Maldives                                            | No information obtained for this report                          |                                                        |               |                     |                     |                                                          |                            |                               |
| Myanmar                                             | National data, incomplete                                        |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Nepal                                               | National data                                                    | 48                                                     |               |                     | 225                 | Comprehensive                                            | 2012                       | 2013                          |
| Sri Lanka                                           | National data not available                                      |                                                        |               |                     |                     |                                                          |                            | 2013                          |
| Thailand                                            | National data                                                    | 47                                                     |               |                     | 2581                | Comprehensive                                            | 2012                       | 2013                          |
| Timor-Leste                                         | National data, incomplete, from national laboratory <sup>e</sup> | 4                                                      |               |                     |                     |                                                          | 2010–2012                  | 2013                          |
| International network                               | ANSORP <sup>f</sup>                                              | 4.6 (R + I) <sup>g</sup>                               |               |                     | 2144                | Non-meningitis pneumococcal infections                   | 2008–2009                  | 2012                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

e. Data were provided, but no formal national data compilation was available.

f. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

g. I=Intermediate.



**Table A2.36** *Streptococcus pneumoniae*: Resistance or non-susceptibility to penicillin  
Western Pacific Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                                                                                      | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%)            | No. tested isolates                               | Type of surveillance, population or samples <sup>b</sup>                                                         | Period for data collection                                        | Year of publication or report |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|---------------|--------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------|
| Australia                                           | National data                                                                                                       | 2.0                                                    |               |                                | 1831                                              | Comprehensive                                                                                                    | 2007                                                              | 2013                          |
| Brunei Darussalam                                   | National data from hospital laboratory                                                                              | 15.4                                                   |               |                                | 76                                                | Comprehensive                                                                                                    | 2012                                                              | 2013                          |
| Cambodia                                            | National data not available                                                                                         |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   | 2013                          |
| Cambodia                                            | National data <sup>d</sup> collected from several sources by public health institute (NIPH). Pasteur Institute (PI) | 0 (NIPH, surveillance network);                        |               | 64 (NIPH, Hospital); 63.9 (PI) | 17 (Surveillance network); 11 (Hospital); 47 (PI) | NIPH data: Sputum, blood (Surveillance network); Blood isolates (hospital); PI: Laboratory data (mixed patients) | 2007–2013 (Surveillance network); 2007–2010 (Hospital); 2013 (PI) | 2013                          |
| China                                               | National data                                                                                                       |                                                        |               | 1.9                            | 420                                               | Targeted                                                                                                         | 2010                                                              | 2013                          |
| Cook Islands                                        | No information obtained for this report                                                                             |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   |                               |
| Fiji                                                | National data compilation not available                                                                             |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   | 2013                          |
| Fiji                                                | Institute surveillance <sup>d, e</sup>                                                                              | 1.1                                                    |               |                                | 86                                                |                                                                                                                  | 2012                                                              | 2013                          |
| Japan                                               | National data                                                                                                       | 42.2                                                   |               | 42.2                           | 30 484                                            | Comprehensive                                                                                                    | 2012                                                              | 2013                          |
| Kiribati                                            | National data                                                                                                       |                                                        |               |                                | 1                                                 | Comprehensive                                                                                                    | 2013                                                              | 2013                          |
| Lao People's Democratic Republic                    | National data                                                                                                       |                                                        | 66.7          |                                | 3                                                 |                                                                                                                  | 2013                                                              | 2013                          |
| Lao People's Democratic Republic                    | Institute surveillance                                                                                              |                                                        | 0             |                                | 2                                                 | Comprehensive (Laboratory)                                                                                       | 2011–2012                                                         | 2013                          |
| Malaysia                                            | National data                                                                                                       |                                                        |               | 17.5                           | 848                                               | Comprehensive                                                                                                    | 2012                                                              | 2013                          |
| Marshall Islands                                    | National data not available                                                                                         |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   | 2013                          |
| Micronesia                                          | National data                                                                                                       | "Insignificant"                                        |               |                                | ≤30                                               | Comprehensive                                                                                                    | 2011                                                              | 2013                          |
| Mongolia                                            | Publication (99)                                                                                                    |                                                        | 96.7          |                                | 153                                               | Community infections                                                                                             | 2011                                                              | 2013                          |
| Nauru                                               | No information obtained for this report                                                                             |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   |                               |
| New Zealand                                         | National data                                                                                                       | 14.9                                                   |               |                                | 2993                                              | Comprehensive                                                                                                    | 2011                                                              | 2013                          |
| Niue                                                | No information obtained for this report                                                                             |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   |                               |
| Palau                                               | No information obtained for this report                                                                             |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   |                               |
| Papua New Guinea                                    | National data                                                                                                       | 30                                                     |               |                                | 10                                                | Blood isolates                                                                                                   | 2012                                                              | 2013                          |
| Philippines                                         | National data                                                                                                       | 0                                                      |               |                                | 43                                                | Comprehensive                                                                                                    | 2012                                                              | 2013                          |
| Republic of Korea                                   | National data                                                                                                       | 0 <sup>f</sup>                                         |               |                                | 270                                               | Comprehensive                                                                                                    | 2011                                                              | 2013                          |
| Republic of Korea                                   | National network/ institute surveillance                                                                            | 89                                                     |               |                                | 347                                               | Hospital samples                                                                                                 | 2012                                                              | 2013                          |
| Samoa                                               | National data                                                                                                       | 8                                                      |               |                                | 25                                                |                                                                                                                  | 2011                                                              | 2013                          |
| Singapore                                           | National data not available                                                                                         |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   | 2013                          |
| Singapore                                           | Publication (258)                                                                                                   |                                                        | 44            |                                | 147                                               | Invasive infections                                                                                              | 1997–2004                                                         | 2008                          |
| Singapore                                           | Publication (259)                                                                                                   |                                                        |               | 0 (Non-meningitis)             | 186 (Non-meningitis)                              | Invasive infections                                                                                              | 2000–2007                                                         | 2009                          |
| Singapore                                           | Publication (260)                                                                                                   |                                                        |               | 69.5                           | 59                                                | Carriers (children)                                                                                              | (1997)–2007–2008                                                  | 2011                          |
| Solomon Islands                                     | National data                                                                                                       | 47.0                                                   |               |                                | 30                                                |                                                                                                                  | 2012                                                              | 2013                          |
| Tonga                                               | National data                                                                                                       | 0                                                      |               |                                | 30                                                |                                                                                                                  | 2012                                                              | 2013                          |
| Tuvalu                                              | No information obtained for this report                                                                             |                                                        |               |                                |                                                   |                                                                                                                  |                                                                   |                               |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                       | Not specified whether resistant or non-susceptible (%) | Resistant (%) | Non-susceptible (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|--------------------------------------------------------|---------------|---------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Vanuatu                                             | No information obtained for this report              |                                                        |               |                     |                     |                                                          |                            |                               |
| Viet Nam                                            | No information obtained for this report <sup>g</sup> |                                                        |               |                     |                     |                                                          |                            |                               |
| International network                               | ANSORPh                                              | 4.6% (R + I) <sup>i</sup>                              |               |                     | 2144                | Non-meningitis pneumococcal infections                   | 2008–2009                  | 2012                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Data were provided, but no formal national data compilation was available.

e. Data from two hospitals aggregated.

f. Data aggregated from more than one surveillance source ("Hospitals" and "Clinics").

g. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

h. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

i. I=intermediate.

**Table A2.37 Nontyphoidal *Salmonella* (NTS): Resistance to fluoroquinolones  
African region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Angola                                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Benin                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Botswana                                            | National data                           | 1.6            | 61                  | Stool isolates                                           | 2012                       | 2013                          |
| Burkina Faso                                        | National data not available             |                |                     |                                                          |                            | 2013                          |
| Burkina Faso                                        | Publication (261)                       | 1              | 25                  | Children with diarrhoea                                  | 2009–2010                  | 2013                          |
| Burundi                                             | National data                           | 14.2           | 14                  |                                                          | 2012                       | 2013                          |
| Cameroon                                            | No information obtained for this report |                |                     |                                                          |                            |                               |
| Cabo Verde                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Central African Republic                            | National data                           | 0              | 114                 |                                                          |                            | 2013                          |
| Chad                                                | No information obtained for this report |                |                     |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Congo                                               | National data                           | 1.65           | 61                  | Stool isolates                                           | 2012                       | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report |                |                     |                                                          |                            |                               |
| Democratic Republic of the Congo                    | Publication (262)                       | 1.3            | 79                  |                                                          | 2010–2011                  | 2012                          |
| Equatorial Guinea                                   | No information obtained for this report |                |                     |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Ethiopia                                            | National data                           | 14             | 8                   |                                                          |                            | 2013                          |
| Ethiopia                                            | Publication (263)                       | 0              | 37                  | Persons with and without diarrhoea                       | 1992–1993                  | 2008                          |
| Ethiopia                                            | Publication (264)                       | 8.9            | 214                 | Hospital patients                                        |                            | 2008                          |
| Gabon                                               | No information obtained for this report |                |                     |                                                          |                            |                               |
| Gambia                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Ghana                                               | National data                           | 0              | 9                   | All isolates                                             | 2013                       | 2013                          |
| Ghana                                               | Publication (265)                       | 0              | 247                 | Clinical isolates                                        | 2002–2003                  | 2011                          |
| Ghana                                               | Publication (266)                       | 0              | 113                 | Blood isolates, (children)                               | 2007–2009                  | 2010                          |
| Guinea                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Guinea-Bissau                                       | National data, incomplete               |                | 2                   | All isolates                                             |                            | 2013                          |
| Kenya                                               | National data, incomplete               | 2              |                     |                                                          | 2012                       | 2013                          |
| Kenya                                               | National network <sup>d</sup>           | 0              | 1                   | Targeted                                                 | 2013                       | 2013                          |
| Kenya                                               | Publication (267)                       | 0              | 23                  | Children with diarrhoea                                  | 2007                       | 2008                          |
| Lesotho                                             | National data                           | 0              | 2                   |                                                          | 2012                       | 2013                          |
| Liberia                                             | National data                           | 0              | 4                   | Targeted                                                 | 2012                       | 2013                          |
| Madagascar                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Malawi                                              | National data                           | 0              | 4                   |                                                          | 2013                       | 2013                          |
| Malawi                                              | Publication (154)                       | 0              | 22                  | Clinical isolates                                        | 2006–2007                  | 2012                          |
| Mali                                                | No information obtained for this report |                |                     |                                                          |                            |                               |
| Mauritania                                          | National data                           | 35             | 68                  | All isolates                                             | 2013                       | 2013                          |
| Mauritius                                           | National data                           | 3.2            | 124                 | All stool isolates                                       | 2012                       | 2013                          |
| Mozambique                                          | Publication (268)                       | 0              | 40                  | Children under 5 years                                   | 2001–2003                  | 2009                          |
| Namibia                                             | National data                           | 8              | 171                 |                                                          | 2012                       | 2013                          |
| Niger                                               | National data                           | 0              | 1                   | Comprehensive                                            | 2013                       | 2013                          |
| Nigeria                                             | Publication (4)                         | 30             | 30                  | Blood isolates children                                  | 2006–2008                  | 2009                          |
| Rwanda                                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Sao Tome and Principe                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Senegal                                             | Publication (269)                       | 0              | 62                  | AIDS patients                                            | 1996–2005                  | 2008                          |
| Senegal                                             | Publication (270)                       | 0              | 249                 | Laboratory based                                         | 2004–2006                  | 2008                          |
| Seychelles                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                |                     |                                                          |                            |                               |
| South Africa                                        | National data                           | 3              | 2137                | Comprehensive                                            | 2012                       | 2013                          |
| South Sudan                                         | National data not available             |                |                     |                                                          |                            | 2013                          |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup> | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup>                  | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------|----------------|---------------------|---------------------------------------------------------------------------|----------------------------|-------------------------------|
| Swaziland                                           | National data not available    |                |                     |                                                                           |                            | 2013                          |
| Togo                                                | Publication (271)              | 0              | 51                  | Blood isolates ( <i>S. enterica</i> serovars Enteritidis and Typhimurium) | 1995–2004                  | 2008                          |
| Uganda                                              | National data                  | 6.7            | 15                  | Comprehensive                                                             | 2012                       | 2013                          |
| Uganda                                              | Publication (238)              | 0              | 42                  | HIV patients with blood stream infection                                  | 2006–2007                  | 2010                          |
| United Republic of Tanzania                         | National data not available    |                |                     |                                                                           |                            | 2013                          |
| United Republic of Tanzania                         | Publication (272)              | 8              | 13                  | Febrile HIV-patients                                                      |                            | 2012                          |
| United Republic of Tanzania                         | Publication (17)               | 0              | 6                   | Hospitalized children with diarrhoea                                      | 2005–2006                  | 2011                          |
| Zambia                                              | National data                  | 13.5           | 97                  | Targeted                                                                  | 2012                       | 2013                          |
| Zimbabwe                                            | National data                  | 0              | 50                  | Comprehensive                                                             | 2013                       | 2013                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Global Disease Detection Center, Kenya/Division of Global Health Protection/Center for Global Health/CDC (US Centers for Disease Control and Prevention).

**Table A2.38 Nontyphoidal *Salmonella* (NTS): Resistance to fluoroquinolones  
Region of the Americas**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%) | No. tested isolates                                                   | Type of surveillance, population or samples <sup>b</sup>                       | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Argentina                                           | National data                           | 3              | 452                                                                   | Community isolates                                                             | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Barbados                                            | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Belize                                              | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 12             | 60                                                                    | Community isolates                                                             | 2010                       | 2013                          |
| Brazil                                              | National data                           | 2              | 7221                                                                  | Community isolates                                                             | 2010                       | 2013                          |
| Canada                                              | National data                           | 0              | 996                                                                   | Laboratory samples                                                             | 2011                       | 2013                          |
| Chile                                               | National data                           | 0.3            | 384                                                                   | Community isolates                                                             | 2010                       | 2013                          |
| Colombia                                            | National data                           | 0.4            | 240<br>( <i>S. enteritidis</i> );<br>217<br>( <i>S. typhimurium</i> ) | <i>S. enterica</i><br>serovars<br><i>Enteritidis</i> and<br><i>Typhimurium</i> | 2010                       | 2013                          |
| Costa Rica                                          | National data                           | 0              | 2                                                                     |                                                                                | 2010                       | 2013                          |
| Cuba                                                | National data                           | 0              | 20                                                                    | Community isolates                                                             | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Dominican Republic                                  | National data                           | 3              | 26                                                                    | Community isolates                                                             | 2009                       | 2013                          |
| Ecuador                                             | National data                           | 0              | 16                                                                    | Community isolates                                                             | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 0              | 21                                                                    | Community isolates                                                             | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Guatemala                                           | National data, incomplete <sup>d</sup>  |                |                                                                       |                                                                                |                            | 2013                          |
| Guyana                                              | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Haiti                                               | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Honduras                                            | National data                           | 6              | 75                                                                    | Community isolates                                                             | 2010                       | 2013                          |
| Jamaica                                             | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Mexico                                              | National data                           | 0              | 188                                                                   | Community isolates                                                             | 2010                       | 2013                          |
| Nicaragua                                           | National data                           | 0              | 11                                                                    | Community isolates                                                             | 2010                       | 2013                          |
| Panama                                              | National data                           | 10             | 102                                                                   | Community isolates                                                             | 2010                       | 2013                          |
| Panama                                              | National network                        | 12             | 126                                                                   |                                                                                | 2010                       | 2013                          |
| Paraguay                                            | National data                           | 0              | 116                                                                   | Community isolates                                                             |                            | 2013                          |
| Peru                                                | National data                           | 96             | 42                                                                    | Community isolates<br>( <i>S. enteritidis</i> )                                | 2010                       | 2013                          |
| Peru                                                | National network                        | 23             | 66                                                                    | Comprehensive                                                                  | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Suriname                                            | No information obtained for this report |                |                                                                       |                                                                                |                            |                               |
| Trinidad and Tobago                                 | Publication (116)                       | 0              | 8                                                                     | Hospitalized children                                                          | 2007                       | 2010                          |
| United States of America                            | National data                           | 0              | 2474                                                                  |                                                                                |                            | 2013                          |
| Uruguay                                             | National data not available             |                |                                                                       |                                                                                |                            | 2013                          |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup> | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup>                       | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------|----------------|---------------------|--------------------------------------------------------------------------------|----------------------------|-------------------------------|
| Uruguay                                             | Publication (273)              | 0              | 258                 | Only <i>Salmonella enterica</i> subspecies <i>enterica</i> serovar Typhimurium | 1976–2000                  | 2009                          |
| Venezuela (Bolivarian Republic of)                  | National data                  | 0              | 44                  | Community isolates                                                             | 2010                       | 2013                          |

- a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.
- b. See Annex 1 for definitions.
- c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.
- d. Serotype specific data available.

**Table A2.39 Nontyphoidal *Salmonella* (NTS): Resistance to fluoroquinolones  
Eastern Mediterranean Region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                     | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|----------------------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report            |                |                     |                                                          |                            |                               |
| Bahrain                                             | National data not available                        |                |                     |                                                          |                            | 2013                          |
| Djibouti                                            | No information obtained for this report            |                |                     |                                                          |                            |                               |
| Egypt                                               | National data not available                        |                |                     |                                                          |                            | 2013                          |
| Iran (Islamic Republic of)                          | National data                                      | 6.3            | 125                 | Invasive isolates                                        |                            | 2013                          |
| Iraq                                                | No information obtained for this report            |                |                     |                                                          |                            |                               |
| Jordan                                              | National data                                      | 49.1           | 387                 | Comprehensive                                            | 2011                       | 2013                          |
| Kuwait                                              | National data from international publication (274) | 1.6            | 247                 | Patients with diarrhoea and septicaemia.                 | 2003–2005                  | 2008                          |
| Lebanon                                             | National data not available                        |                |                     |                                                          |                            | 2013                          |
| Libya                                               | No information obtained for this report            |                |                     |                                                          |                            |                               |
| Libya                                               | Publication (275)                                  | 63.1           | 19                  | Children with diarrhoea                                  | 2008                       | 2011                          |
| Morocco                                             | National data not available                        |                |                     |                                                          |                            | 2013                          |
| Morocco                                             | Publication (276)                                  | 0              | 150                 |                                                          | 2000–2008                  | 2010                          |
| Oman                                                | National data                                      | 2              | 60                  | Comprehensive                                            | 2012                       | 2013                          |
| Pakistan                                            | National data, incomplete                          | 15             |                     | Targeted                                                 |                            | 2013                          |
| Qatar                                               | No information obtained for this report            |                |                     |                                                          |                            |                               |
| Saudi Arabia                                        | Publication (277)                                  | 46             | 213                 | Hospital patients                                        | 2007–2009                  | 2012                          |
| Somalia                                             | No information obtained for this report            |                |                     |                                                          |                            |                               |
| Sudan                                               | National data not available                        |                |                     |                                                          |                            | 2013                          |
| Syrian Arab Republic                                | National data not available                        |                |                     |                                                          |                            | 2013                          |
| Tunisia                                             | No information obtained for this report            |                |                     |                                                          |                            |                               |
| United Arab Emirates <sup>d</sup>                   | National data                                      | 13.2           | 257                 | Comprehensive                                            | 2012                       | 2013                          |
| United Arab Emirates                                | National data from international publication (274) | 0.8            | 122                 | Patients with diarrhoea and septicaemia                  | 2003–2005                  | 2008                          |
| Yemen                                               | Publication (278)                                  | 0.7            | 406                 | Patients with diarrhoea                                  | 2003–2005                  | 2008                          |
| International network                               | ANSORP <sup>e</sup>                                | 4.5            | 400                 |                                                          | 2003–2005                  | 2009                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Data from United Arab Emirates originate from Abu Dhabi only.

e. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.40 Nontyphoidal *Salmonella* (NTS): Resistance to fluoroquinolones  
European Region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%)    | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|-------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Albania                                             | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Andorra                                             | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Armenia                                             | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Austria                                             | National data                           | 0.7               | 2235                | All isolates                                             | 2011                       | 2013                          |
| Azerbaijan                                          | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Belarus                                             | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Belgium                                             | National data not available             |                   |                     | All isolates                                             | 2011                       | 2013                          |
| Belgium                                             | Publication (279)                       | 0                 | 22                  |                                                          | 2000–2006                  | 2011                          |
| Bosnia and Herzegovina                              | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Bulgaria                                            | National data not available             |                   |                     |                                                          | 2011                       | 2013                          |
| Croatia                                             | National data                           | 0                 | 2858                | Comprehensive                                            | 2012                       | 2013                          |
| Cyprus                                              | National data not available             |                   |                     |                                                          | 2011                       | 2013                          |
| Czech Republic                                      | National surveillance                   | 3.8               | 637                 | All isolates                                             | 2012                       | 2013                          |
| Denmark                                             | National data                           | 14.6 <sup>d</sup> | 1149                | All isolates                                             | 2010                       | 2013                          |
| Estonia                                             | National data                           | 1.1               | 359                 | All isolates                                             | 2011                       | 2013                          |
| Finland                                             | National data                           | 20.6              | 1978                | All isolates                                             | 2012                       | 2013                          |
| France                                              | National data                           | 9                 | 1367                | All isolates                                             | 2011                       | 2013                          |
| Georgia                                             | National data                           | 0                 | 16                  | All isolates                                             | 2012                       | 2013                          |
| Germany                                             | National data                           | 1.1               | 1933                | All isolates                                             | 2011                       | 2013                          |
| Greece                                              | National data                           | 0                 | 363                 | All isolates                                             | 2012                       | 2013                          |
| Hungary                                             | National data                           | 0.1               | 697                 | All isolates                                             | 2011                       | 2013                          |
| Iceland                                             | National data                           | 4.5               | 44                  | All isolates                                             | 2011                       | 2013                          |
| Ireland                                             | National data                           | 1                 | 304                 | All isolates                                             | 2011                       | 2013                          |
| Israel                                              | Publication (280)                       | 13.3              | 1490                |                                                          | 2002–2007                  | 2012                          |
| Italy                                               | National data                           | 11.3              | 1522                | All isolates                                             | 2011                       | 2013                          |
| Kazakhstan                                          | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Kyrgyzstan                                          | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Latvia                                              | National data                           | 0                 | 105                 | All isolates                                             | 2011                       | 2013                          |
| Lithuania                                           | National data                           | 0.7               | 1800                | All isolates                                             | 2011                       | 2013                          |
| Luxembourg                                          | National data                           | 4.1               | 123                 | All isolates                                             | 2011                       | 2013                          |
| Malta                                               | National data                           | 9.2               | 120                 | All isolates                                             | 2011                       | 2013                          |
| Monaco                                              | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Montenegro                                          | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Netherlands                                         | National data                           | 10.2              | 1115                | All isolates                                             | 2011                       | 2013                          |
| Norway                                              | National data                           | 2.2               | 1245                | All isolates                                             | 2011                       | 2013                          |
| Poland                                              | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Portugal                                            | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Republic of Moldova                                 | National data                           | 4.2               | 310                 |                                                          | 2012                       | 2013                          |
| Romania                                             | National data                           | 0.7               | 281                 | All isolates                                             | 2011                       | 2013                          |
| Russian Federation                                  | National data not available             |                   |                     |                                                          |                            | 2013                          |
| San Marino                                          | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Serbia                                              | National data                           | 8.7               | 1756                | <i>S. enteritidis</i>                                    | 2004–2010                  | 2013                          |
| Slovakia                                            | National data                           | 3.2               | 249                 | All isolates                                             | 2011                       | 2013                          |
| Slovenia                                            | National data                           | 0.3               | 400                 | All isolates                                             | 2011                       | 2013                          |
| Spain                                               | National data                           | 0.7               | 2110                | All isolates                                             | 2011                       | 2013                          |
| Sweden                                              | National data                           | 21                | 66                  | Blood isolates                                           | 2011                       | 2013                          |
| Switzerland                                         | National data                           | 8                 | 327                 | All isolates                                             | 2012                       | 2013                          |
| Tajikistan                                          | No information obtained for this report |                   |                     |                                                          |                            |                               |
| The former Yugoslav Republic of Macedonia           | National data not available             |                   |                     |                                                          |                            | 2013                          |
| Turkey                                              | National data                           | 1.1               | 378                 | All isolates                                             | 2011                       | 2013                          |
| Turkmenistan                                        | No information obtained for this report |                   |                     |                                                          |                            |                               |
| Ukraine                                             | No information obtained for this report |                   |                     |                                                          |                            |                               |
| United Kingdom                                      | National data                           | 17.6              | 9354                | All isolates                                             | 2011                       | 2013                          |
| Uzbekistan                                          | No information obtained for this report |                   |                     |                                                          |                            |                               |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Proportion of non-wild type as resistance was interpreted using EUCAST ECOFF values, not clinical breakpoints.



**Table A2.41 Nontyphoidal *Salmonella* (NTS): Resistance to fluoroquinolones  
South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>           | Resistance (%)        | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------|-----------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available              |                       |                     |                                                          |                            | 2013                          |
| Bangladesh                                          | Publication (281)                        | 1.4                   | 958                 | Patients with diarrhoea                                  | 2005–2008                  | 2012                          |
| Bhutan                                              | National data                            | 0                     | 5                   | Comprehensive                                            | 2011–2012                  | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report  |                       |                     |                                                          |                            |                               |
| India                                               | National data not available <sup>d</sup> |                       |                     |                                                          |                            | 2013                          |
| Indonesia                                           | National data not available <sup>d</sup> |                       |                     |                                                          |                            | 2013                          |
| Maldives                                            | No information obtained for this report  |                       |                     |                                                          |                            |                               |
| Myanmar                                             | National data                            |                       |                     |                                                          |                            | 2013                          |
| Nepal                                               | National data                            | 4                     | 1102                | Comprehensive                                            | 2012                       | 2013                          |
| Sri Lanka                                           | National data not available              |                       |                     |                                                          |                            | 2013                          |
| Thailand                                            | National data                            | 0.2 (nor);<br>4 (cip) | 1483                |                                                          | 2012                       | 2013                          |
| Timor–Leste                                         | National data not available              |                       |                     |                                                          |                            | 2013                          |
| International network                               | ANSORP <sup>d</sup>                      | 4.5                   | 400                 |                                                          | 2003–2005                  | 2009                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Some centres from the following countries, territories and areas participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.42 Nontyphoidal *Salmonella* (NTS): Resistance to fluoroquinolones  
Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                                         | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Australia                                           | National data not available                                            |                |                     |                                                          |                            | 2013                          |
| Brunei Darussalam                                   | National data (hospital laboratory)                                    | 0              | 51                  | Comprehensive                                            | 2012                       | 2013                          |
| Cambodia                                            | National data <sup>d</sup> collected by public health institute (NIPH) | 2.3            | 88                  | Blood and stool samples                                  | 2007–2013                  | 2013                          |
| China                                               | National data                                                          | 11.9           | 177                 |                                                          | 2011                       | 2013                          |
| Cook Islands                                        | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| Fiji                                                | National data compilation not available                                |                |                     |                                                          |                            | 2013                          |
| Fiji                                                | Institute surveillance <sup>d, e</sup>                                 | 0.3            | 383                 |                                                          | 2012                       | 2013                          |
| Japan                                               | National data                                                          | 2              | 1966                | Comprehensive                                            | 2011                       | 2013                          |
| Kiribati                                            | National data                                                          | 0              | 1                   | Comprehensive                                            | 2013                       | 2013                          |
| Lao People's Democratic Republic                    | National data                                                          | 1.3            | 75                  |                                                          | 2012–2013                  | 2013                          |
| Lao People's Democratic Republic                    | Institute surveillance                                                 | 9.1            | 11                  | Comprehensive                                            | 2011–2012                  | 2013                          |
| Malaysia                                            | National data                                                          | 1.3            | 1787                | Comprehensive                                            | 2012                       | 2013                          |
| Marshall Islands                                    | National data not available                                            |                |                     |                                                          |                            | 2013                          |
| Micronesia                                          | National data                                                          |                | ≤30                 | Comprehensive                                            | 2011                       | 2013                          |
| Mongolia                                            | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| Nauru                                               | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| New Zealand                                         | National data                                                          | 0.5            | 222                 | Clinical isolates                                        |                            | 2013                          |
| Niue                                                | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| Palau                                               | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| Papua New Guinea                                    | National data                                                          | 33.3           | 15                  | Blood and stool isolates                                 | 2012                       | 2013                          |
| Philippines                                         | National data                                                          | 14.3           | 98                  | Comprehensive                                            | 2012                       | 2013                          |
| Republic of Korea                                   | National data not available                                            |                |                     |                                                          |                            | 2013                          |
| Republic of Korea                                   | National network                                                       | 0              | 38                  | Laboratory network, comprehensive                        | 2012                       | 2013                          |
| Samoa                                               | National data                                                          | 0              | 102                 | Blood and stool isolates                                 | 2011                       | 2013                          |
| Singapore <sup>f</sup>                              | National data not available                                            |                |                     |                                                          |                            | 2013                          |
| Solomon Islands                                     | National data not available                                            |                |                     |                                                          |                            | 2013                          |
| Tonga                                               | National data not available                                            |                |                     |                                                          |                            | 2013                          |
| Tuvalu                                              | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| Vanuatu                                             | No information obtained for this report                                |                |                     |                                                          |                            |                               |
| Viet Nam                                            | No information obtained for this report <sup>f</sup>                   |                |                     |                                                          |                            |                               |
| International network                               | ANSORP <sup>g</sup>                                                    | 4.5            | 400                 |                                                          | 2003–2005                  | 2009                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Data were provided, but no formal national data compilation was available.

e. Data from two hospitals aggregated.

f. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

g. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.43** *Shigella* species: Resistance to fluoroquinolones  
African Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Angola                                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Benin                                               | National data                           | 0              | 1                   | Invasive                                                 | 2012                       | 2013                          |
| Botswana                                            | National data                           | 2.9            | 34                  | Stool samples                                            | 2012                       | 2013                          |
| Burkina Faso                                        | National data not available             |                |                     |                                                          |                            | 2013                          |
| Burkina Faso                                        | Publication (261)                       | 0              | 16                  | Children with diarrhoea                                  | 2009–2010                  | 2013                          |
| Burundi                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Cameroon                                            | No information obtained for this report |                |                     |                                                          |                            |                               |
| Cabo Verde                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Central African Republic                            | National data                           | 0              | 60                  | Comprehensive                                            | 2012                       |                               |
| Chad                                                | No information obtained for this report |                |                     |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Congo                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Côte d'Ivoire                                       | No information obtained for this report |                |                     |                                                          |                            |                               |
| Democratic Republic of the Congo                    | No information obtained for this report |                |                     |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report |                |                     |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Ethiopia                                            | National data                           | 0              | 7                   | Comprehensive                                            | 2012                       | 2013                          |
| Ethiopia                                            | Publication (282)                       | 9.2            | 65                  | Patients with diarrhoea, teaching hospital               | 2005                       | 2008                          |
| Ethiopia                                            | Publication (263)                       | 0              | 76                  | Children with and without diarrhoea                      | 1992–1993                  | 2008                          |
| Ethiopia                                            | Publication (283)                       | 2.2            | 90                  | Hospital patients                                        | 2006–2008                  | 2009                          |
| Ethiopia                                            | Publication (264)                       | 8.9            | 214                 | Hospital patients                                        |                            | 2008                          |
| Gabon                                               | No information obtained for this report |                |                     |                                                          |                            |                               |
| Gambia                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Ghana                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Ghana                                               | Publication (284)                       | 0              | 5                   | Children with and without diarrhoea                      |                            | 2008                          |
| Guinea                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Guinea-Bissau                                       | National data not available             |                |                     |                                                          |                            | 2013                          |
| Kenya                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Kenya                                               | National network <sup>d</sup>           | 0              | 1                   | Targeted                                                 | 2013                       | 2013                          |
| Kenya                                               | Publication (285)                       | 1              | 181                 | Population based surveillance                            | 2006–2009                  | 2009                          |
| Kenya                                               | Publication (286)                       | 1              | 224                 | Population based surveillance                            | 2007–2011                  | 2013                          |
| Lesotho                                             | National data                           | 0              | 1                   |                                                          | 2012                       | 2013                          |
| Liberia                                             | National data                           | 0              | 3                   | Targeted                                                 | 2012                       | 2013                          |
| Madagascar                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Malawi                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Mali                                                | No information obtained for this report |                |                     |                                                          |                            |                               |
| Mauritania                                          | National data not available             |                |                     |                                                          |                            | 2013                          |
| Mauritius                                           | National data                           | 25             | 4                   | All stool isolates                                       | 2012                       | 2013                          |
| Mozambique                                          | Publication (268)                       | 0              | 109                 | Children with diarrhoea                                  | 2001–2003                  | 2009                          |
| Namibia                                             | National data                           | 1              | 58                  |                                                          | 2012                       | 2013                          |
| Niger                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Nigeria                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Rwanda                                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Sao Tome and Principe                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Senegal                                             | Publication (287)                       | 0.6            | 165                 | Outpatients                                              | 2004–2006                  | 2008                          |

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Seychelles                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report |                |                     |                                                          |                            |                               |
| South Africa                                        | National data                           | 0.06           | 1639                | Comprehensive                                            | 2012                       | 2013                          |
| South Sudan                                         | National data not available             |                |                     |                                                          |                            | 2013                          |
| Swaziland                                           | National data not available             |                |                     |                                                          |                            | 2013                          |
| Togo                                                | No information obtained for this report |                |                     |                                                          |                            |                               |
| Uganda                                              | National data                           | 0              | 3                   | Comprehensive                                            | 2012                       | 2013                          |
| United Republic of Tanzania                         | National data not available             |                |                     |                                                          |                            | 2013                          |
| United Republic of Tanzania                         | Publication (17)                        | 0              | 15                  | Hospitalized children with diarrhoea                     | 2005–2006                  | 2011                          |
| Zambia                                              | National data                           | 15.4           | 28                  | Targeted                                                 | 2012                       | 2013                          |
| Zimbabwe                                            | National data                           | 0              | 15                  | Comprehensive                                            | 2013                       | 2013                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Global Disease Detection Center, Kenya/Division of Global Health Protection/Center for Global Health/CDC (US Centers for Disease Control and Prevention).

**Table A2.44** *Shigella* species: Resistance to fluoroquinolones  
Region of the Americas

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%)                                            | No. tested isolates                                     | Type of surveillance, population or samples <sup>b</sup>     | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|-----------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Argentina                                           | National data                           | 0.1                                                       | 2288                                                    | <i>S. flexneri</i> + <i>S. sonnei</i>                        | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Barbados                                            | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Belize                                              | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Bolivia (Plurinational State of)                    | National data                           | 3                                                         | 122                                                     |                                                              | 2010                       | 2013                          |
| Brazil                                              | National data                           | 1.3                                                       | 77                                                      | Community isolates ( <i>S. flexneri</i> + <i>S. sonnei</i> ) | 2010                       | 2013                          |
| Canada                                              | National data not available             |                                                           |                                                         |                                                              |                            | 2013                          |
| Canada                                              | Publication (288)                       | 14.9 ( <i>S. sonnei</i> );<br>20.1 ( <i>S. flexneri</i> ) | 222 ( <i>S. sonnei</i> );<br>164 ( <i>S. flexneri</i> ) | Travel related cases                                         | 2002–2007                  | 2010                          |
| Chile                                               | National data                           | 8                                                         | 51                                                      | Community isolates ( <i>S. flexneri</i> )                    | 2010                       | 2013                          |
| Colombia                                            | National data                           | 0                                                         | 286                                                     | <i>S. flexneri</i> + <i>S. sonnei</i>                        | 2010                       | 2013                          |
| Costa Rica                                          | National data                           | 0                                                         | 148                                                     | <i>S. boydii</i> + <i>S. flexneri</i> + <i>S. sonnei</i>     | 2010                       | 2013                          |
| Cuba                                                | National data                           | 0                                                         | 50                                                      | Community isolates                                           | 2009                       | 2013                          |
| Dominica                                            | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Dominican Republic                                  | National data                           | 2                                                         | 20                                                      | Community isolates                                           | 2009                       | 2013                          |
| Ecuador                                             | National data                           | 0                                                         | 55                                                      | <i>S. boydii</i> + <i>S. flexneri</i> + <i>S. sonnei</i>     | 2010                       | 2013                          |
| El Salvador                                         | National data                           | 0                                                         | 39                                                      | <i>S. flexneri</i> + <i>S. sonnei</i>                        | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Guatemala                                           | National data                           | 0                                                         | 3                                                       | <i>S. flexneri</i>                                           | 2010                       | 2013                          |
| Guyana                                              | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Haiti                                               | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Honduras                                            | National data                           | 4                                                         | 52                                                      | Community isolates                                           | 2010                       | 2013                          |
| Jamaica                                             | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Mexico                                              | National data                           | 0                                                         | 2                                                       | Community isolates                                           | 2010                       | 2013                          |
| Nicaragua                                           | National data                           | 0                                                         | 6                                                       | Community isolates                                           | 2010                       | 2013                          |
| Panama                                              | National data                           | 0                                                         | 19                                                      | Community isolates                                           | 2010                       | 2013                          |
| Panama                                              | National network                        | 3                                                         | 27                                                      | Comprehensive                                                | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                           | 0                                                         | 153                                                     | <i>S. flexneri</i> + <i>S. sonnei</i>                        | 2010                       | 2013                          |
| Peru                                                | National data                           | 0                                                         | 121                                                     | <i>S. flexneri</i>                                           | 2010                       | 2013                          |
| Peru                                                | National network                        | 1                                                         | 117                                                     | Comprehensive                                                | 2012                       | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Saint Lucia                                         | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Suriname                                            | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| Trinidad and Tobago                                 | No information obtained for this report |                                                           |                                                         |                                                              |                            |                               |
| United States of America                            | National data                           | 2                                                         | 407                                                     |                                                              | 2010                       | 2013                          |
| Uruguay                                             | National data not available             |                                                           |                                                         |                                                              |                            | 2013                          |
| Uruguay                                             | Publication (289)                       | 0                                                         | 51                                                      | Children with bloody diarrhoea                               | 2001–2008                  | 2010                          |
| Venezuela (Bolivarian Republic of)                  | National data                           | 0                                                         | 51                                                      | Community isolates                                           | 2010                       | 2013                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

**Table A2.45** *Shigella* species: Resistance to fluoroquinolones  
Eastern Mediterranean Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                       | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|------------------------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report              |                |                     |                                                          |                            |                               |
| Bahrain                                             | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Djibouti                                            | No information obtained for this report              |                |                     |                                                          |                            |                               |
| Egypt                                               | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Iran (Islamic Republic of)                          | National data                                        | 2.7            | 260                 | Targeted                                                 | 2012                       | 2013                          |
| Iraq                                                | No information obtained for this report              |                |                     |                                                          |                            |                               |
| Jordan                                              | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Kuwait                                              | Publication (290)                                    | 0              | 42                  | Patients with diarrhoea                                  | 2003–2005                  | 2010                          |
| Lebanon                                             | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Libya                                               | No information obtained for this report              |                |                     |                                                          |                            |                               |
| Morocco                                             | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Oman                                                | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Oman                                                | Publication (291)                                    | 0              | 91                  | Children                                                 | 2000–2002                  | 2008                          |
| Pakistan                                            | National data, incomplete                            | 5              |                     |                                                          |                            | 2013                          |
| Pakistan                                            | Publication (292)                                    | 3.3            | 394                 | Patients with diarrhoea                                  | 2002–2004                  | 2009                          |
| Pakistan                                            | Publication (293)                                    | 1.7            | 1573                | Symptomatic                                              | 1996–2007                  | 2009                          |
| Pakistan                                            | Publication (294)                                    | 0              | 40                  | Children with diarrhoea                                  |                            | 2011                          |
| Qatar                                               | No information obtained for this report              |                |                     |                                                          |                            |                               |
| Saudi Arabia                                        | No information obtained for this report <sup>d</sup> |                |                     |                                                          |                            |                               |
| Somalia                                             | No information obtained for this report              |                |                     |                                                          |                            |                               |
| Sudan                                               | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Sudan                                               | Publication (295)                                    | 41.3           | 46                  | Patients with diarrhoea                                  | 2006–2007                  | 2009                          |
| Syrian Arab Republic                                | National data not available                          |                |                     |                                                          |                            | 2013                          |
| Tunisia                                             | No information obtained for this report              |                |                     |                                                          |                            |                               |
| United Arab Emirates                                | National data <sup>f</sup>                           | 10.2           | 49                  | Comprehensive                                            | 2012                       | 2013                          |
| Yemen                                               | No information obtained for this report              |                |                     |                                                          |                            |                               |
| International network                               | ANSORP <sup>f</sup>                                  | 10             | 98                  | Comprehensive                                            | 2001–2004                  | 2008                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

e. Data from United Arab Emirates originate from Abu Dhabi only.

f. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Taiwan, China, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.46** *Shigella* species: Resistance to fluoroquinolones  
European Region

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Albania                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Andorra                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Armenia                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Austria                                             | National data                           | 24.4           | 45                  | Stool samples                                            | 2011                       | 2013                          |
| Azerbaijan                                          | National data not available             |                |                     |                                                          |                            | 2013                          |
| Belarus                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| Belgium                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Belgium                                             | Publication (279)                       | 0              | 43                  | Returning travelers                                      | 2000–2006                  | 2011                          |
| Belgium                                             | Publication (296)                       | 0              | 7307                | Shigella sonnei isolates (national reference laboratory) | 1990–2007                  | 2009                          |
| Bosnia and Herzegovina                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Bulgaria                                            | National data not available             |                |                     |                                                          |                            | 2013                          |
| Croatia                                             | National data                           | 13             | 24                  | Comprehensive                                            |                            |                               |
| Cyprus                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Czech Republic                                      | National data not available             |                |                     |                                                          |                            | 2013                          |
| Denmark                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Estonia                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Finland                                             | National data                           | 46.9           | 98                  | Comprehensive                                            | 2012                       | 2013                          |
| France                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Georgia                                             | National data                           | 0              | 31                  | Comprehensive                                            | 2012                       | 2013                          |
| Germany                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Greece                                              | National data                           | 0              | 59                  | Comprehensive                                            | 2012                       | 2013                          |
| Hungary                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Iceland                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Ireland                                             | National data                           | 13             | 30                  | Stool samples                                            | 2011                       | 2013                          |
| Israel                                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Italy                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Kazakhstan                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Kyrgyzstan                                          | National data not available             |                |                     |                                                          |                            | 2013                          |
| Latvia                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Lithuania                                           | National data not available             |                |                     |                                                          |                            | 2013                          |
| Luxembourg                                          | National data not available             |                |                     |                                                          |                            | 2013                          |
| Malta                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Monaco                                              | No information obtained for this report |                |                     |                                                          |                            |                               |
| Montenegro                                          | National data not available             |                |                     |                                                          |                            | 2013                          |
| Netherlands                                         | National data not available             |                |                     |                                                          |                            | 2013                          |
| Norway                                              | National data                           | 14.4           | 111                 | Comprehensive                                            | 2011                       | 2013                          |
| Poland                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Portugal                                            | National data not available             |                |                     |                                                          |                            | 2013                          |
| Republic of Moldova                                 | National data                           | 9.2            | 324                 |                                                          | 2012                       | 2013                          |
| Romania                                             | National data not available             |                |                     |                                                          |                            | 2013                          |
| Russian Federation                                  | National data not available             |                |                     |                                                          |                            | 2013                          |
| San Marino                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| Serbia                                              | National data                           | 0.5            | 382                 | Comprehensive                                            | 2005–2011                  | 2013                          |
| Slovakia                                            | National data not available             |                |                     |                                                          |                            | 2013                          |
| Slovenia                                            | National data not available             |                |                     |                                                          |                            | 2013                          |
| Spain                                               | National data not available             |                |                     |                                                          |                            | 2013                          |
| Sweden                                              | National data not available             |                |                     |                                                          |                            | 2013                          |
| Switzerland                                         | National data                           | 13.2           | 53                  | Comprehensive                                            | 2012                       | 2013                          |
| Tajikistan                                          | No information obtained for this report |                |                     |                                                          |                            |                               |
| The former Yugoslav Republic of Macedonia           | National data not available             |                |                     |                                                          |                            | 2013                          |
| Turkey                                              | National data                           | 0              | 108                 | Comprehensive                                            | 2011                       | 2013                          |
| Turkmenistan                                        | No information obtained for this report |                |                     |                                                          |                            |                               |
| Ukraine                                             | No information obtained for this report |                |                     |                                                          |                            |                               |
| United Kingdom                                      | National data not available             |                |                     |                                                          |                            | 2013                          |
| Uzbekistan                                          | No information obtained for this report |                |                     |                                                          |                            |                               |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

**Table A2.47 *Shigella* species: Resistance to fluoroquinolones  
South East Asian Region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>           | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection    | Year of publication or report |
|-----------------------------------------------------|------------------------------------------|----------------|---------------------|----------------------------------------------------------|-------------------------------|-------------------------------|
| Bangladesh                                          | National data not available              |                |                     |                                                          |                               | 2013                          |
| Bangladesh                                          | Publication (281)                        | 8.5            | 634                 | Patients with diarrhoea                                  | 2005–2008                     | 2012                          |
| Bhutan                                              | National data not available              |                |                     |                                                          |                               | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report  |                |                     |                                                          |                               |                               |
| India                                               | National data not available              |                |                     |                                                          |                               | 2013                          |
| India                                               | Publication (297)                        | 82             | 50                  | Children with diarrhoea                                  | 2006–2009                     | 2012                          |
| India                                               | Publication (298)                        | 0              | 73                  | Children with diarrhoea                                  | 2009–2012                     | 2012                          |
| India                                               | Publication (299)                        | 71             | 88                  | Stool samples                                            | 2003–2007                     | 2008                          |
| India                                               | Publication (300)                        | 47.4           | 59                  | Children with diarrhoea                                  | (2001–2006)–2007 <sup>d</sup> | 2010                          |
| India                                               | Publication (301)                        | 50             | 74                  | Patients with diarrhoea                                  | 2008–2010                     | 2012                          |
| India                                               | Publication (302)                        | 48             | 154 (all years)     | Patients with dysentery                                  | (2002)–2007                   | 2009                          |
| India                                               | Publication (303)                        | 11.2           | 71                  | Patients with diarrhoea                                  | 2008–2010                     | 2013                          |
| Indonesia                                           | National data not available <sup>e</sup> |                |                     |                                                          |                               | 2013                          |
| Maldives                                            | No information obtained for this report  |                |                     |                                                          |                               |                               |
| Myanmar                                             | National data not available              |                |                     |                                                          |                               | 2013                          |
| Nepal                                               | National data                            | 17             | 14                  | Comprehensive                                            | 2012                          | 2013                          |
| Nepal                                               | Publication (304)                        | 5.7            | 35                  | Children with diarrhoea                                  | 2007                          | 2009                          |
| Nepal                                               | Publication (305)                        | 0              | 51                  | Traveller's diarrhoea                                    | 2001–2003                     | 2011                          |
| Nepal                                               | Publication (306)                        | 17             | 41                  | NRL                                                      | 2002–2004                     | 2011                          |
| Sri Lanka                                           | National data not available              |                |                     |                                                          |                               | 2013                          |
| Thailand                                            | National data, incomplete                |                | 76                  | Comprehensive                                            | 2012                          | 2013                          |
| Timor-Leste                                         | National data not available              |                |                     |                                                          |                               | 2013                          |
| International network                               | ANSORP <sup>f</sup>                      | 10             | 98                  | Comprehensive                                            | 2001–2004                     | 2008                          |

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

e. Some centres participate in some ANSORP (Asian Network for Surveillance of Resistant Pathogens) projects.

f. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Taiwan, China, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.



**Table A2.48 *Shigella*: Resistance to fluoroquinolones**  
**Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>a, b, c</sup>                                                       | Resistance (%)        | No. tested isolates | Type of surveillance, population or samples <sup>b</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Australia                                           | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Brunei Darussalam                                   | National data not available                                                          |                       | 0                   |                                                          |                            | 2013                          |
| Cambodia                                            | National data <sup>d</sup> collected from several sources by public health institute | 11.8                  | 76                  | Stool samples                                            | 2008–2013                  | 2013                          |
| China                                               | National data                                                                        | 27.9 (cip); 9.7 (lev) | 308                 | Comprehensive                                            | 2011                       | 2013                          |
| Cook Islands                                        | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| Fiji                                                | National data compilation not available                                              |                       |                     |                                                          |                            | 2013                          |
| Fiji                                                | Institute surveillance <sup>d, e</sup>                                               | 0                     | 102                 |                                                          | 2012                       | 2013                          |
| Japan                                               | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Kiribati                                            | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Lao People's Democratic Republic                    | National data <sup>d</sup>                                                           | 0                     | 33                  |                                                          | 2013                       | 2013                          |
| Malaysia                                            | National data                                                                        | 2.9                   | 35                  | All isolates                                             | 2012                       | 2013                          |
| Marshall Islands                                    | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Micronesia                                          | National data                                                                        | "Insignificant"       | ≤30                 | Comprehensive                                            | 2011                       | 2013                          |
| Mongolia                                            | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| Nauru                                               | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| New Zealand                                         | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Niue                                                | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| Palau                                               | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| Papua New Guinea                                    | National data                                                                        | 0                     | 53                  | Stool samples                                            | 2012                       | 2013                          |
| Philippines                                         | National data                                                                        | 44.4                  | 9                   | Comprehensive                                            | 2012                       | 2013                          |
| Republic of Korea                                   | National data not available                                                          |                       |                     |                                                          |                            |                               |
| Samoa                                               | National data                                                                        | 0                     | 2                   | Stool samples                                            | 2011                       | 2013                          |
| Singapore                                           | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Solomon Islands                                     | National data not available                                                          |                       |                     |                                                          |                            | 2013                          |
| Tonga                                               | National data, incomplete                                                            | 0                     |                     |                                                          | 2012                       | 2013                          |
| Tuvalu                                              | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| Vanuatu                                             | No information obtained for this report                                              |                       |                     |                                                          |                            |                               |
| Viet Nam                                            | Publication (307)                                                                    | 2                     | 103                 | Stool samples                                            | 2006–2008                  | 2009                          |
| International                                       | ANSORP <sup>g</sup> (308)                                                            | 10                    | 98                  | Comprehensive                                            | 2001–2004                  | 2008                          |

cip, ciprofloxacin; lev, levofloxacin.

a. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

b. See Annex 1 for definitions.

c. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

d. Data were provided, but no formal national data compilation was available.

e. Data from two hospitals aggregated. One hospital included all isolates, the other hospital did not specify.

f. No information obtained, or incomplete.

g. Some centres from the following countries, territories and areas participate in some ANSORP projects: India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Sri Lanka, Saudi Arabia, Taiwan, China, Thailand, Viet Nam, in addition to China, Hong Kong SAR (Special Administrative Region) and Taiwan, China.

**Table A2.49** *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>  
African Region

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>            | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-------------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Algeria                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Angola                                              | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Benin                                               | National data, incomplete                 |                |                     |                                                          |                            | 2013                          |
| Botswana                                            | National data not available               |                |                     |                                                          |                            | 2013                          |
| Burkina Faso                                        | National data not available               |                |                     |                                                          |                            | 2013                          |
| Burundi                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Cameroon                                            | Data from international publication (309) | 0              | 79                  |                                                          | 2004–2005                  | 2008                          |
| Cabo Verde                                          | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Central African Republic                            | National data                             | 0              | 1                   |                                                          | 2013                       | 2013                          |
| Central African Republic                            | Data from international publication (309) | 0              | 39                  |                                                          | 2004–2005                  | 2008                          |
| Chad                                                | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Comoros                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Congo                                               | National data not available               |                |                     |                                                          |                            | 2013                          |
| Côte d'Ivoire                                       | Report to GASP <sup>e</sup>               | "NC"           | 12                  | Sentinel site                                            | 2010                       | 2013                          |
| Democratic Republic of the Congo                    | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Equatorial Guinea                                   | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Eritrea                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Ethiopia                                            | National data not available               |                |                     |                                                          |                            | 2013                          |
| Gabon                                               | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Gambia                                              | National data not available               |                |                     |                                                          |                            | 2013                          |
| Ghana                                               | National data not available               |                |                     |                                                          |                            | 2013                          |
| Guinea                                              | National data not available               |                |                     |                                                          |                            | 2013                          |
| Guinea-Bissau                                       | Report to GASP                            | 0              | 6                   |                                                          |                            | 2013                          |
| Kenya                                               | Publication (310)                         | 0              | 168                 | Men undergoing circumcision                              | 2002–2009                  | 2011                          |
| Lesotho                                             | Report to GASP                            | 0              | 1                   |                                                          | 2012                       | 2013                          |
| Liberia                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Madagascar                                          | Data from international publication (309) | 0              | 126                 |                                                          | 2004–2005                  | 2008                          |
| Malawi                                              | National data                             | 0              | 0                   | Comprehensive                                            | 2013                       | 2013                          |
| Mali                                                | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Mauritania                                          | Report to GASP                            | 0              | 2                   | Comprehensive                                            | 2013                       | 2013                          |
| Mauritius                                           | Report to GASP                            | 0              | 24                  | Comprehensive                                            | 2012                       | 2013                          |
| Mozambique                                          | Publication (311)                         | 0              | 22                  | Cross-sectional study                                    |                            | 2009                          |
| Namibia                                             | Report to GASP                            | 0              | 3                   |                                                          | 2012                       | 2013                          |
| Niger                                               | National data not available               |                |                     |                                                          |                            | 2013                          |
| Nigeria                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Rwanda                                              | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Sao Tome and Principe                               | National data not available               |                |                     |                                                          |                            | 2013                          |
| Senegal                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Seychelles                                          | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Sierra Leone                                        | No information obtained for this report   |                |                     |                                                          |                            |                               |
| South Africa                                        | Report to GASP                            | 0              | 120                 | Comprehensive                                            | 2012                       | 2013                          |
| South Sudan                                         | National data not available               |                |                     |                                                          |                            | 2013                          |
| Swaziland                                           | National data not available               |                |                     |                                                          |                            | 2013                          |
| Togo                                                | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Uganda                                              | National data not available               |                |                     |                                                          |                            | 2013                          |
| Uganda                                              | Publication (312)                         | 0              | 151                 |                                                          | 2007–2011                  | 2012                          |

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup> | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|--------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| United Republic of Tanzania                         | National data not available    |                |                     |                                                          |                            | 2013                          |
| Zambia                                              | National data not available    |                |                     |                                                          |                            | 2013                          |
| Zimbabwe                                            | National data                  | 12.3           | 57                  | Comprehensive                                            | 2012                       | 2013                          |

a. cfm, cefixim; cro, ceftriaxone

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. GASP, Gonococcal Antimicrobial Surveillance Programme.

**Table A2.50** *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>  
Region of the Americas

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>                      | Resistance (%)          | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------------------|-------------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Antigua and Barbuda                                 | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Argentina                                           | Report to GASP <sup>e</sup>                         | 0                       | 316                 | Sentinel site                                            | 2010                       | 2013                          |
| Bahamas                                             | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Barbados                                            | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Belize                                              | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Bolivia (Plurinational State of)                    | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Brazil                                              | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Canada                                              | Report to GASP                                      | 31                      | 155                 | Comprehensive                                            | 2010                       | 2012                          |
| Chile                                               | Report to GASP                                      | 0                       | 508                 |                                                          | 2010                       | 2013                          |
| Colombia                                            | Report to GASP                                      | Not tested              | 45                  |                                                          | 2010                       | 2013                          |
| Costa Rica                                          | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Cuba                                                | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Dominica                                            | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Dominican Republic                                  | National data                                       | 0                       | 3                   |                                                          |                            | 2013                          |
| Ecuador                                             | Report to GASP                                      | 0                       | 6                   |                                                          | 2010                       | 2013                          |
| El Salvador                                         | Report to GASP                                      | 0                       | 14                  |                                                          | 2010                       | 2013                          |
| Grenada                                             | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Guatemala                                           | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Guyana                                              | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Haiti                                               | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Honduras                                            | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Jamaica                                             | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Mexico                                              | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Nicaragua                                           | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Panama                                              | Report to GASP                                      | 0                       | 1                   |                                                          | 2010                       | 2013                          |
| Panama                                              | National network                                    | 0                       | 10                  | Comprehensive                                            | 2011–2012                  | 2013                          |
| Paraguay                                            | National data                                       | 0                       | 13                  |                                                          | 2010                       | 2013                          |
| Peru                                                | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Saint Kitts and Nevis                               | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Saint Lucia                                         | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Saint Vincent and the Grenadines                    | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Suriname                                            | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| Trinidad and Tobago                                 | No information obtained for this report             |                         |                     |                                                          |                            |                               |
| United States of America                            | National data – GISP <sup>e</sup> –reported to GASP | 1.4 (cfm),<br>0.4 (cro) | 5467                | Comprehensive                                            | 2011                       | 2012                          |
| Uruguay                                             | National data not available                         |                         |                     |                                                          |                            | 2013                          |
| Venezuela (Bolivarian Republic of)                  | Report to GASP                                      | 0                       | 14                  |                                                          | 2010                       | 2013                          |
| International                                       | Publication (313)                                   | 7                       | 110                 |                                                          | 2000–2009                  | 2012                          |

a. cfm, cefixim; cro, ceftriaxone.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. GASP, Gonococcal Antimicrobial Surveillance Programme.

f. GISP, Gonococcal Isolate Surveillance Project.

**Table A2.51** *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>  
Eastern Mediterranean region

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>e</sup> | Period for data collection    | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|----------------|---------------------|----------------------------------------------------------|-------------------------------|-------------------------------|
| Afghanistan                                         | No information obtained for this report |                |                     |                                                          |                               |                               |
| Bahrain                                             | Report to GASP <sup>e</sup>             | 0              | 41                  |                                                          | 2012                          | 2013                          |
| Djibouti                                            | No information obtained for this report |                |                     |                                                          |                               |                               |
| Egypt                                               | National data not available             |                |                     |                                                          |                               | 2013                          |
| Iran (Islamic Republic of)                          | National data not available             |                |                     |                                                          |                               | 2013                          |
| Iraq                                                | No information obtained for this report |                |                     |                                                          |                               |                               |
| Jordan                                              | National data not available             |                |                     |                                                          |                               | 2013                          |
| Kuwait                                              | No information obtained for this report |                |                     |                                                          |                               |                               |
| Lebanon                                             | National data not available             |                |                     |                                                          |                               | 2013                          |
| Libya                                               | No information obtained for this report |                |                     |                                                          |                               |                               |
| Morocco                                             | Report to GASP                          | 0              | 72                  | National survey                                          | 2009                          | 2013                          |
| Oman                                                | National data not available             |                |                     |                                                          |                               |                               |
| Pakistan                                            | National data, incomplete               | 12             |                     | Targeted                                                 |                               | 2013                          |
| Pakistan                                            | Publication (314)                       | 0              | 106                 | Clinical samples                                         | (1992)–2007–2009 <sup>f</sup> | 2011                          |
| Qatar                                               | No information obtained for this report |                |                     |                                                          |                               |                               |
| Saudi Arabia                                        | Publication (315)                       | 0              | 8                   | Random samples from pregnant women                       | 2005–2006                     | 2010                          |
| Somalia                                             | No information obtained for this report |                |                     |                                                          |                               |                               |
| Sudan                                               | National data not available             |                |                     |                                                          |                               | 2013                          |
| Syrian Arab Republic                                | National data not available             |                |                     |                                                          |                               | 2013                          |
| Tunisia                                             | No information obtained for this report |                |                     |                                                          |                               |                               |
| United Arab Emirates                                | National data not available             |                |                     |                                                          |                               | 2013                          |
| Yemen                                               | No information obtained for this report |                |                     |                                                          |                               |                               |

a. cfm, cefixim; cro, ceftriaxon.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. GASP, Gonococcal Antimicrobial Surveillance Programme.

f. For data from time periods of several years, or where data from a subset of year(s) were available, the format (2001)–2011, indicates the first year of data collection within parenthesis, and the most recent year with separate data outside the parenthesis.

**Table A2.52 *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>**  
**European Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>            | Resistance (%) | No. tested isolates | Type of surveillance, population or samples <sup>e</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-------------------------------------------|----------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Albania                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Andorra                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Armenia                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Austria                                             | Report to EURO-GASP <sup>e</sup>          | 13.2           | 106                 | Comprehensive                                            | 2011                       | 2013                          |
| Azerbaijan                                          | National data not available               |                |                     |                                                          |                            | 2013                          |
| Belarus                                             | Publication (316)                         | 0              | 80                  | Clinical isolates                                        | 2009                       | 2011                          |
| Belgium                                             | Report to EURO-GASP                       | 0.9            | 110                 | Comprehensive                                            | 2011                       | 2013                          |
| Bosnia and Herzegovina                              | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Bulgaria                                            | National data not available               |                |                     |                                                          |                            | 2013                          |
| Croatia                                             | National data not available               |                |                     |                                                          |                            |                               |
| Cyprus                                              | Report to EURO-GASP                       | 10             | 10                  | Comprehensive                                            | 2011                       | 2013                          |
| Czech Republic                                      | National data not available               |                |                     |                                                          |                            | 2013                          |
| Denmark                                             | Report to EURO-GASP                       | 25             | 110                 | Comprehensive                                            | 2011                       | 2013                          |
| Estonia                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Finland                                             | National data                             | 2.1            | 145                 | Comprehensive                                            | 2011                       | 2013                          |
| France                                              | Report to EURO-GASP                       | 0              | 109                 | Comprehensive                                            | 2011                       | 2013                          |
| Georgia                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Germany                                             | Report to EURO-GASP                       | 10.2           | 108                 | Comprehensive                                            | 2011                       | 2013                          |
| Greece                                              | Report to EURO-GASP                       | 3.0            | 100                 | Comprehensive                                            | 2011                       | 2013                          |
| Hungary                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Iceland                                             | National data not available               |                |                     |                                                          |                            | 2013                          |
| Ireland                                             | Report to EURO-GASP                       | 3.1            | 64                  | Comprehensive                                            | 2011                       | 2013                          |
| Israel                                              | Publication (317)                         | 0.0            | 406                 | STI patients                                             | 2002–2007                  | 2010                          |
| Italy                                               | Report to EURO-GASP                       | 3.0            | 99                  | Comprehensive                                            | 2011                       | 2013                          |
| Kazakhstan                                          | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Kyrgyzstan                                          | National data not available               |                |                     |                                                          |                            | 2013                          |
| Latvia                                              | Report to EURO-GASP                       | 0.0            | 28                  | Comprehensive                                            | 2011                       | 2013                          |
| Lithuania                                           | National data not available               |                |                     |                                                          |                            | 2013                          |
| Luxembourg                                          | National data not available               |                |                     |                                                          |                            | 2013                          |
| Malta                                               | Report to EURO-GASP                       | 7.7            | 13                  | Comprehensive                                            | 2011                       | 2013                          |
| Monaco                                              | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Montenegro                                          | National data not available               |                |                     |                                                          |                            | 2013                          |
| Netherlands                                         | Report to EURO-GASP                       | 0.0            | 217                 | Comprehensive                                            | 2011                       | 2013                          |
| Norway                                              | Report to EURO-GASP                       | 1.3            | 77                  | Comprehensive                                            | 2011                       | 2013                          |
| Poland                                              | National data not available               |                |                     |                                                          |                            | 2013                          |
| Portugal                                            | Report to EURO-GASP                       | 0.0            | 109                 | Comprehensive                                            | 2011                       | 2013                          |
| Republic of Moldova                                 | National data not available               |                |                     |                                                          |                            | 2013                          |
| Romania                                             | Report to EURO-GASP                       | 15.4           | 26                  | Comprehensive                                            | 2011                       | 2013                          |
| Russian Federation                                  | Publication (318)                         | 0.0            | 407                 | Surveillance sites                                       | 2010                       | 2011                          |
| San Marino                                          | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Serbia                                              | National data not available               |                |                     |                                                          |                            | 2013                          |
| Slovakia                                            | Report to EURO-GASP                       | 36.3           | 113                 | Comprehensive                                            | 2011                       | 2013                          |
| Slovenia                                            | Report to EURO-GASP                       | 36.8           | 19                  | Comprehensive                                            | 2011                       | 2013                          |
| Spain                                               | Report to EURO-GASP                       | 15.0           | 100                 | Comprehensive                                            | 2011                       | 2013                          |
| Sweden                                              | Report to EURO-GASP                       | 7.6            | 105                 | Comprehensive                                            | 2011                       | 2013                          |
| Switzerland                                         | National data                             | 1.9            | 107                 | Targeted                                                 | 2012                       | 2013                          |
| Tajikistan                                          | No information obtained for this report   |                |                     |                                                          |                            |                               |
| The former Yugoslav Republic of Macedonia           | National data not available               |                |                     |                                                          |                            | 2013                          |
| Turkey                                              | National data not available               |                |                     |                                                          |                            | 2013                          |
| Turkmenistan                                        | No information obtained for this report   |                |                     |                                                          |                            |                               |
| Ukraine                                             | No information obtained for this report   |                |                     |                                                          |                            |                               |
| United Kingdom                                      | Report - GRASP <sup>f</sup> to EURO-GASP  | 2.8            | 251                 | Comprehensive                                            | 2011                       | 2013                          |
| Uzbekistan                                          | No information obtained for this report   |                |                     |                                                          |                            |                               |
| International                                       | International publication/EURO GASP (319) | 0.0            | 1285                | Laboratory study                                         | 2006–2008                  | 2010                          |

a. cfo, ceftriaxone; cfm, cefixim.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. GASP, Gonococcal Antimicrobial Surveillance Programme. EURO-GASP data forwarded by ECDC (European Centre for Disease Prevention and Control) or from GASP.

f. GRASP, The Gonococcal Resistance to Antimicrobials Surveillance Programme.

**Table A2.53** *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>  
South East Asian Region

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)            | No. tested isolates | Type of surveillance, population or samples <sup>c</sup> | Period for data collection | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|---------------------------|---------------------|----------------------------------------------------------|----------------------------|-------------------------------|
| Bangladesh                                          | National data not available             |                           |                     |                                                          |                            | 2013                          |
| Bhutan                                              | Report to GASP <sup>e</sup>             | 2.2                       | 181                 |                                                          | 2010                       | 2012                          |
| Bhutan                                              | National data                           | 0.16                      | 1111                | Comprehensive                                            | 2008–2012                  | 2013                          |
| Democratic People's Republic of Korea               | No information obtained for this report |                           |                     |                                                          |                            |                               |
| India                                               | Report to GASP (320)                    | 3.9                       | 51                  | Comprehensive                                            | 2010                       | 2012                          |
| Indonesia                                           | Report to GASP                          | 1.92 (cfm);<br>2.88 (cro) | 218                 | Sex workers                                              | 2013                       | 2013                          |
| Maldives                                            | No information obtained for this report |                           |                     |                                                          |                            |                               |
| Myanmar                                             | National data                           | 18                        | 22                  |                                                          | 2012                       | 2013                          |
| Nepal                                               | National data                           | 0                         | 7                   | Comprehensive                                            | 2012                       | 2013                          |
| Sri Lanka                                           | Report to GASP (320)                    | 0                         | 75                  | Comprehensive                                            | 2010                       | 2012                          |
| Thailand                                            | Report to GASP                          | 0                         | 213                 | Comprehensive                                            | 2012                       | 2013                          |
| Timor-Leste                                         | National data not available             |                           |                     |                                                          |                            | 2013                          |

a. cfm, cefixim; cro, ceftriaxon.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. GASP, Gonococcal Antimicrobial Surveillance Programme.

**Table A2.54 *Neisseria gonorrhoeae*: Decreased susceptibility to third-generation cephalosporins<sup>a</sup>**  
**Western Pacific Region**

| Countries, territories and other areas or groupings | Data source <sup>b, c, d</sup>          | Resistance (%)                                                     | No. tested isolates                   | Type of surveillance, population or samples <sup>c</sup> | Period for data collection        | Year of publication or report |
|-----------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------|---------------------------------------|----------------------------------------------------------|-----------------------------------|-------------------------------|
| Australia                                           | National data <sup>e</sup>              | 3.6 (urban), 0.4 (remote)                                          | 3647 (urban), 459 (remote)            | Comprehensive                                            | 2012                              | 2013                          |
| Brunei Darussalam                                   | Report to GASP <sup>f</sup>             | 1.0                                                                | 295                                   | Comprehensive                                            | 2011                              | 2013                          |
| Brunei Darussalam                                   | National data                           | 0.96                                                               | 207                                   | Comprehensive                                            | 2012                              | 2013                          |
| Cambodia                                            | National data not available             |                                                                    |                                       |                                                          |                                   | 2013                          |
| Cambodia                                            | Report to GASP                          | NI                                                                 | 6                                     | Sentinel site                                            | 2010                              | 2012                          |
| China                                               | Report to GASP                          | 21 (Mainland), 1.6 (Hong Kong SAR (Special Administrative Region)) | 1349 (Mainland); 1225 (Hong Kong SAR) | Comprehensive                                            | 2011                              | 2013                          |
| China                                               | National data                           | 0.8 (Mainland), 3.8 (Hong Kong SAR)                                | NI (Mainland); 569 (Hong Kong SAR)    |                                                          | 2006 (mainland), 2010 (Hong Kong) |                               |
| Cook Islands                                        | No information obtained for this report |                                                                    |                                       |                                                          |                                   |                               |
| Fiji                                                | Report to GASP                          | 0.4                                                                | 541*                                  |                                                          | 2010                              | 2012                          |
| Japan                                               | Report to GASP (320)                    | 4.8                                                                | 441                                   | Comprehensive                                            | 2011                              | 2013                          |
| Kiribati                                            | National data                           | -                                                                  | 0                                     |                                                          |                                   | 2013                          |
| Lao People's Democratic Republic                    | National data                           | 0                                                                  | 24                                    |                                                          | 2012–2013                         | 2013                          |
| Malaysia                                            | National data                           | 1.8                                                                | 109                                   | Comprehensive                                            | 2012                              | 2013                          |
| Marshall Islands                                    | National data not available             |                                                                    |                                       |                                                          |                                   |                               |
| Micronesia                                          | National data                           | "Insignificant"                                                    | <30                                   | Comprehensive                                            | 2011                              | 2013                          |
| Mongolia                                            | Report to GASP                          | 30.7                                                               | 150                                   |                                                          | 2010                              | 2012                          |
| Nauru                                               | No information obtained for this report |                                                                    |                                       |                                                          |                                   |                               |
| New Caledonia                                       | Report to GASP (320)                    | 0                                                                  | 81                                    | Comprehensive                                            | 2010                              | 2012                          |
| New Zealand                                         | Report to GASP (320)                    | 3.2                                                                | 317                                   | Comprehensive                                            | 2010                              | 2012                          |
| Niue                                                | No information obtained for this report |                                                                    |                                       |                                                          |                                   |                               |
| Palau                                               | No information obtained for this report |                                                                    |                                       |                                                          |                                   |                               |
| Papua New Guinea                                    | National data not available             |                                                                    |                                       |                                                          |                                   | 2013                          |
| Papua New Guinea                                    | Report to GASP                          |                                                                    | 0                                     |                                                          |                                   | 2013                          |
| Philippines                                         | Report to GASP (320)                    | 0                                                                  | 34                                    | Sentinel site                                            | 2011                              |                               |
| Republic of Korea                                   | Data to GASP                            | 25                                                                 | 64                                    | Comprehensive                                            | 2011                              | 2013                          |
| Republic of Korea                                   | National data                           | 0                                                                  | 61                                    | Comprehensive                                            | 2011                              | 2013                          |
| Republic of Korea                                   | Surveillance network                    | 0                                                                  | 91                                    | Comprehensive                                            | 2012                              | 2013                          |
| Samoa                                               | National data                           | 0                                                                  | 5                                     | Sexually transmitted infection (STI) clinics             | 2011                              | 2013                          |
| Singapore                                           | Report to GASP                          | 6.9                                                                | 160                                   | Comprehensive                                            | 2010                              | 2012                          |
| Singapore                                           | National data                           | 14.1                                                               | 148                                   | STI clinics                                              | 2012                              | 2013                          |
| Solomon Islands                                     | National data                           | 10                                                                 | 10                                    |                                                          | 2012                              | 2013                          |
| Tonga                                               | Report to GASP (320)                    | 0                                                                  | 4                                     | Comprehensive                                            | 2010                              | 2012                          |
| Tonga                                               | National data, incomplete               | 0                                                                  |                                       |                                                          | 2012                              | 2013                          |
| Tuvalu                                              | No information obtained for this report |                                                                    |                                       |                                                          |                                   |                               |
| Vanuatu                                             | No information obtained for this report |                                                                    |                                       |                                                          |                                   |                               |
| Viet Nam                                            | Report to GASP                          | 1.3                                                                | 75                                    | Sentinel site                                            | 2011                              | 2013                          |

a. ceftriaxone; cfm, cefixim.

b. National data refers to data returned on the questionnaires as defined in Annex 1. This definition does not imply that the data collected is representative for that country as a whole because information gaps are likely.

c. See Annex 1 for definitions.

d. "National data not available" means that there was information that no data were available; "No information obtained for this report" means that no information was obtained from authorities, networks or publications.

e. Data from two surveillance systems.

f. GASP, Gonococcal Antimicrobial Surveillance Programme.



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# Annex 3

## The burden of antibacterial resistance: a systematic review of published evidence (technical report on methods and detailed results)

### A3.1 Methods

The strategy for building and analysing the evidence base for the burden of antimicrobial resistance consisted of two fundamental steps based on a predefined systematic review protocol:

(i) A broad systematic review of the available non-randomized evidence in the published literature for the outcomes specified in the protocol was undertaken. The systematic review was conducted in line with the *Cochrane handbook for systematic reviews of interventions* (1).

(ii) A meta-analysis was conducted comparing the available health and economic outcomes specified a priori for resistant and susceptible *Escherichia coli*, *Klebsiella pneumoniae* and *S. aureus* infections. Meta-analysis was done separately by resistance for each *E. coli*, *K. pneumoniae* and *S. aureus* outcome.

#### Population, intervention, comparator and outcome (PICO) statement

The population, intervention, comparator and outcome (PICO) statement is outlined in Table A3.1.

#### A3.1.1 Electronic search strategy

The literature search included the following bibliographic databases: MEDLINE and PubMed, Embase, the Centre for Reviews and Dissemination (DARE, NHS EED and HTA) databases, Web of Knowledge and Global Health (Ovid). Searches (from 1946) were run in March 2013. Where possible, searches were limited to human studies. No date or language limits were applied to the clinical or economics searches, but the search for existing reviews was limited to 2010 to present. The search terms used controlled vocabulary, such as the Medical Subject Headings (MeSH) terms: *Escherichia coli*, *Klebsiella pneumoniae* and *Staphylococcus aureus*, combined with MeSH terms for drug resistance, as well as additional keywords. Each database was searched for observational studies, economic and burden of illness studies, and recent systematic reviews. The comprehensive search strategy is available on request.

**Table A3.1** Population, intervention, comparator and outcome elements for each investigated bacteria

| Population                          | Patients with confirmed:                                                                                                                                                                     |                                                                                |                                                                                                                  |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
|                                     | <i>E. coli</i> infection                                                                                                                                                                     | <i>K. pneumoniae</i> infection                                                 | <i>S. aureus</i> infection                                                                                       |
| Intervention                        | Patients with:                                                                                                                                                                               |                                                                                |                                                                                                                  |
|                                     | 3 <sup>rd</sup> generation cephalosporin-resistant<br>Fluoroquinolone-resistant                                                                                                              | 3 <sup>rd</sup> generation cephalosporin-resistant<br>Carbapenem-resistant     | Methicillin-resistant                                                                                            |
| Comparator                          | 3 <sup>rd</sup> generation cephalosporin-susceptible<br>Fluoroquinolone-susceptible                                                                                                          | 3 <sup>rd</sup> generation cephalosporin-susceptible<br>Carbapenem-susceptible | Methicillin-susceptible                                                                                          |
| Clinical outcomes (health burden)   | Mortality (bacteria-attributable)<br>Mortality (all-cause)<br>30-day mortality<br>LOS in hospital<br>PYLL                                                                                    |                                                                                | Other suggested outcomes<br>ICU required<br>Ventilator need<br>Discharge (to home, care facility)<br>Readmission |
| Economic outcomes (economic burden) | Actual direct hospital costs for treating the patient (second-line drugs, investigations)<br>Secondary costs for hospital/health care: contact testing, isolation room, staff cohorts<br>LOS |                                                                                |                                                                                                                  |
| Outcomes (other)                    | Absenteeism<br>Medical complications leading to physical impairment (short/long term)                                                                                                        |                                                                                |                                                                                                                  |
| Included study types                | All designs including case-series                                                                                                                                                            |                                                                                |                                                                                                                  |
| Subgroups of interest               | Low- and middle-income countries<br>Treatment setting                                                                                                                                        |                                                                                |                                                                                                                  |

ICU, intensive care unit; LOS, length of stay; PYLL, potential years of life loss.

## Eligibility and study selection

Studies were included if the PICO criteria and type of study were appropriate. Selection eligibility criteria were applied to each title and abstract identified in the literature search by two independent reviewers in a standardized manner. Any uncertainties were resolved by discussion and consensus with a third review author. Any study passing the selection criteria was obtained in full-text format. The eligibility criteria were then applied and a final decision made for inclusion. The preliminary inclusion and exclusion criteria for consideration are provided below.

The study must be an approved design, and include:

- human patients with confirmed infection;
- data on outcomes of interest for both resistant and sensitive patients; and
- prospective or retrospective enrolment.

Studies were excluded if they were:

- reports of patients with colonization only ( $\leq 10\%$  within a group allowable); or
- small numbers reported (e.g.  $< 10$  for a case-series).

## Data extraction and management

All information was extracted using a standardized data abstraction form, which was developed, piloted and modified as necessary for this systematic review. Abstraction included the characteristics of study participants and the study itself, along with the relevant health and economic outcomes. All extracted data were checked for accuracy by two independent review authors.

## Risk of bias assessment

Various quality assessment instruments were considered. The Newcastle-Ottawa Scale (NOS) (2) was used for assessing the quality of observational studies. This quality assessment instrument evaluates cohort studies along three dimensions: selection of cohorts, comparability of cohorts and ascertainment of outcome. Issues related specifically to observational studies – including confounding and selective analysis reporting – were carefully evaluated and incorporated into the analysis and interpretation.

## Assessment of heterogeneity

Studies were assessed for both clinical and methodological diversity. Clinical diversity was assessed by checking that the patients, exposures and settings were not so different across studies that combining them would be inappropriate. Methodological diversity was assessed by checking that the studies were similar in terms of study design and risk of bias.

Once satisfied that the studies were minimally diverse (and hence that it made sense to pool them together in a meta-analysis), the statistical heterogeneity was assessed. If the effects observed across studies were inconsistent, and varied to a large extent, the results were again explored to assess whether the differences could be explained by some clinical or methodological feature.

## Assessment of reporting bias

Reporting bias was assessed by constructing funnel plots, as well as bias indicators (e.g. Egger, Harbord-Egger) for each outcome.

## Data synthesis

The data were first summarized descriptively. A meta-analysis was undertaken using fixed or random-effects models when data were available, sufficiently similar and of sufficient quality.

## GRADE tables

Once the review was completed, Grading of Recommendations Assessment, Development and Evaluation (GRADE) tables were prepared using standard GRADE methodology. The quality of outcome measures was assessed using a standard GRADE approach as described by Guyatt et al. (3, 4) The assessment of the items identified in the GRADE risk of bias was based on the NOS assessment of the individual studies. The GRADE evidence table outcome measures were prepared using the GRADEpro program.<sup>a</sup> As described in the GRADE methodology, although evidence derived from observational studies was considered as low-quality evidence supporting an estimate of intervention effect, three factors could result in upgrading of the evidence – large effect, dose response and all plausible confounders or biases would result in an underestimate of the effect size. Ultimately, the quality of evidence for each outcome fell into four categories: very low, low, moderate and high.

<sup>a</sup> <http://ims.cochrane.org/grade-pro>

## A3.2 Results

**Table A3.2** Complete overview of findings addressing the question: *Does the published scientific literature indicate that there is an inferior outcome in infections caused by the following bacteria if they are resistant to the following antibacterial drugs?*

| Parameter                              | <i>E. coli</i>                            |                  | <i>K. pneumoniae</i>                      |                              | <i>S. aureus</i>               |
|----------------------------------------|-------------------------------------------|------------------|-------------------------------------------|------------------------------|--------------------------------|
|                                        | 3 <sup>rd</sup> generation cephalosporins | Fluoroquinolones | 3 <sup>rd</sup> generation cephalosporins | Carbapenems                  | Beta-lactam antibiotics (MRSA) |
|                                        | Outcome                                   |                  |                                           |                              |                                |
| All-cause mortality                    | Yes (n = 16)                              | Yes (n = 8)      | Yes (n = 14)                              | Yes (n = 11)                 | Yes (n = 107)                  |
| Bacterium-attributable mortality       | Yes (n = 4)                               | No (n = 1)       | Yes (n = 4)                               | No (n = 1)                   | Yes (n = 46)                   |
| 30-day mortality                       | Yes (n = 11)                              | Yes (n = 5)      | Yes (n = 7)                               | Yes (n = 3)                  | Yes (n = 16)                   |
| Intensive-care mortality               | ND                                        | ND               | ND                                        | No (n = 1)                   | Yes (n = 5)                    |
| LOS in hospital                        | No (n = 3)                                | No (n = 3)       | No (n = 9)                                | Unclear (n = 3) <sup>a</sup> | Yes (n = 50)                   |
| Admission to ICU                       | No (n = 1)                                | Yes (n = 1)      | Yes (n = 3)                               | ND                           | No (n = 17)                    |
| LOS in ICU                             | ND                                        | ND               | ND                                        | No (n = 1)                   | Yes (n = 21)                   |
| Progression to septic shock            | ND                                        | Yes (n = 1)      | No (n = 3)                                | ND                           | Yes (n = 21)                   |
| Postinfection LOS                      | No (n = 3)                                | ND               | Yes (n = 4)                               | No (n = 1)                   | Yes (n = 27)                   |
| Transfer to other health-care facility | ND                                        | ND               | ND                                        | No (n = 1)                   | Yes (n = 1)                    |
| Transfer to long-term care facility    | ND                                        | ND               | ND                                        | Unclear (n = 1) <sup>b</sup> | Yes (n = 1)                    |
| Attributable readmission               | ND                                        | ND               | ND                                        | ND                           | No (n = 6)                     |
| Attributable mechanical ventilation    | ND                                        | ND               | ND                                        | ND                           | No (n = 14)                    |

ICU, intensive care unit; LOS, length of stay; MRSA, methicillin-resistant *Staphylococcus aureus*; ND, no data.

a. Data in two studies were inconsistent, and a third study could not be included in the analysis.

b. A small study found that there was not a significant increase in the risk of health-care facility transfer for patients with carbapenem-resistant *K. pneumoniae* infections; however, patients enrolled in this study may have come from long-term care facilities at the time of study enrollment, so this result may not be directly attributable to *K. pneumoniae*.



## Health burden

Studies included in the systematic reviews for *E. coli* and *K. pneumoniae* (Table A3.2) were all conducted in countries classified as high or upper-middle-income status according to the 2013 World Bank member list of economies (5). Upper-middle countries include Argentina, Brazil, China, Hungary, Malaysia, Mexico, Romania, South Africa and Thailand. No studies were found that originated from, or studied populations, classified as low income.

## *Escherichia coli*

The literature search identified 17 426 references possibly relevant for the question. Once duplicates were removed, 13 095 references remained, of which 425 were retrieved for full-text review. Ultimately, 12 studies (6-17) met the inclusion criteria for fluoroquinolone resistance and 25 studies (7, 8, 10, 18-39) for resistance to third-generation cephalosporins in *E. coli*. Three studies (7, 8, 10) were included in both *E. coli* reviews. Meta-analysis was done separately for fluoroquinolone and third-generation cephalosporin-resistant *E. coli* for each of the specified outcomes.

### Infections caused by third-generation cephalosporin-resistant *Escherichia coli* infections

From the 25 included studies (Table A3.3) for infections with third-generation cephalosporin-resistant (including extended spectrum beta-lactamases [ESBL]-producing) *E. coli*, results were reported on the following health outcomes, in summary:

- **All-cause mortality:** There was a significant, more than twofold, increase in all-cause mortality in patients with cephalosporin-resistant *E. coli* infections (risk ratio [RR] 2.18, 95% confidence interval [CI]: 1.58 to 3.02,  $P < 0.00001$ ). Data from 16 studies contributed to this estimate and the results were fairly inconsistent across the studies. (8, 20-24, 26, 30, 32-39).
- **Bacterium-attributable mortality:** There was a significant, more than twofold, increase in bacterium-attributable mortality for patients with cephalosporin-resistant *E. coli* infections (RR 2.02, 95% CI: 1.41 to 2.90,  $P < 0.00001$ ). Data from four studies contributed to this estimate and the results were consistent across the studies. (18, 33, 34, 36).
- **30-day mortality:** There was a significant, more than twofold, increase in risk of 30-day mortality in patients with cephalosporin-resistant *E. coli* infections (RR 2.19, 95% CI: 1.78 to 2.68,  $P < 0.00001$ ). Data from 11 studies contributed to this estimate and the results were consistent across the studies. (7, 10, 19, 25, 27-32, 35).

- **Length of stay (LOS) in hospital:** There was no significant increase in LOS for patients with cephalosporin-resistant *E. coli* infections (mean difference [MD] 1.8 days, 95% CI: -1.3 to 5.0,  $P < 0.26$ ). The results were consistent across studies. Four studies reported on LOS (23, 25, 36, 37); for one study no standard deviation (SD) was available, and it could not be combined with the estimates of the other three studies (25).
- **Intensive care unit (ICU) admission:** Only one study (32) considered infection-attributable ICU admission, and there was no significant increase in risk for third-generation cephalosporin-resistant *E. coli* patients (RR 2.78, 95% CI: 0.58 to 13.20,  $P < 0.20$ ).
- **Postinfection LOS in hospital:** There was no significant increase in postinfection LOS for cephalosporin-resistant *E. coli* patients (MD 2.3 days, 95% CI: 0.25 to 4.90,  $P < 0.08$ ). Four studies reported on postinfection LOS (19, 30, 35, 38); for one study (19) no SD was available and it could not be combined with the estimates of the other three studies. The results were consistent across studies.

### Fluoroquinolone-resistant *Escherichia coli* infections

All studies included were conducted in high-income countries. No studies were located from low-income or lower-middle-income countries. From the 12 included studies (6-17) (Table A3.4) results were reported on the following health outcomes comparing patients with fluoroquinolone-resistant *E. coli* to those with fluoroquinolone-susceptible *E. coli*, in summary:

- **All-cause mortality:** There was a significant increase in all-cause mortality for patients with fluoroquinolone-resistant *E. coli* infections, with over a twofold increase in risk of mortality (RR 2.11, 95% CI: 1.64 to 3.71,  $P < 0.00001$ ). Data from eight studies contributed to this estimate and the results were consistent / similar across the studies. (6, 8, 11, 13-17).
- **Bacterium-attributable mortality:** Only one study (11) reported bacterium-attributable mortality. No bacterium-attributable mortality was observed in patients with fluoroquinolone-resistant or susceptible *E. coli*.
- **30-day mortality:** There was a significant increase in 30-day mortality for fluoroquinolone-resistant *E. coli* patients with over a twofold increase in risk (RR 2.16, 95% CI: 1.09 to 4.27,  $P < 0.03$ ). Data from five studies (7, 9, 10, 12, 17) contributed to this estimate and the results were somewhat inconsistent with the estimate from one study (12) that did not indicate greater 30-day mortality in patients with resistant infections.

- **LOS in hospital:** There was no significant increase in LOS for fluoroquinolone-resistant *E. coli* patients (MD 3.73, 95% CI: 3.49 to 10.94, *P* 0.31). However, data from the two studies (11, 17) that contributed to this estimate were inconsistent, with the estimate from one study indicating a significant increase in LOS (MD 7.8 days, 95% CI: 2.9 to 12.7) whereas the results of the other study were not significant (MD 0.40 days, 95% CI: -1.3 to 2.1). One additional study (12) was not included in the analysis due to missing information (SDs of the mean differences not reported).
- **ICU admission:** A single study (9) showed a significant twofold risk increase in infection-attributable ICU admission for fluoroquinolone-resistant *E. coli* patients (RR 2.40, 95% CI: 1.08 to 5.35, *P* 0.03).
- **Progression to septic shock:** Two studies (9, 11) reported on septic shock following *E. coli* infection. There was a significant increase in septic shock in patients with fluoroquinolone-resistant *E. coli* infections (RR 10.00, 95% CI: 1.19 to 84.36, *P* 0.03). This imprecise estimate was based on only one study (9), since no septic shock events occurred during the other study and the corresponding risk ratio (RR) was not estimable.

### *Klebsiella pneumoniae*

The literature search identified 17 426 references possibly relevant for the question. Once duplicates were removed, 13 095 remained, of which 444 references were retrieved for full-text review. Ultimately, 24 studies (29, 40-62) met the inclusion criteria for third-generation cephalosporin *K. pneumoniae* and 13 studies (63-75) met the inclusion criteria for carbapenem-resistant *K. pneumoniae*.

### Third-generation cephalosporin-resistant *Klebsiella pneumoniae* infections

Of the 24 included studies (Table A3.5) 13 were conducted in upper-middle-income countries and 10 in high-income countries, and a single study involved centres from mixed upper-middle- and high-income countries. From the included studies, results were reported on the following health outcomes for infections with third-generation cephalosporin-resistant (i.e. ESBL) *K. pneumoniae*, in summary:

- **All-cause mortality:** There was a significant increase in all-cause mortality for patients with infections caused by third-generation cephalosporin-resistant *K. pneumoniae* (RR 1.35, 95% CI: 1.14 to 1.61, *P* 0.0007). Data from 14 studies (29, 40-42, 44-46, 48, 49, 51, 54, 58, 60, 61) contributed to this estimate and the results were consistent across the studies.
- **Bacterium-attributable mortality:** There was a significant increase in bacterium-attributable mortality in patients with infections caused by third-generation cephalosporin-resistant *K. pneumoniae* (RR 1.93, 95% CI: 1.13 to 3.31, *P* 0.02). Data from four studies (42, 46, 57, 62) contributed to this estimate and the results were consistent across the studies.
- **30-day mortality:** There was a significant increase in 30-day mortality in patients with infections caused by third-generation cephalosporin-resistant *K. pneumoniae* (RR 1.45, 95% CI: 1.07 to 1.95, *P* 0.02). Data from seven studies (29, 43, 47, 52, 53, 55, 56) contributed to this estimate and the results were somewhat consistent across the studies.
- **LOS in hospital:** There was no significant increase in LOS in patients with infections caused by third-generation cephalosporin-resistant *K. pneumoniae* (MD 15.8 days, 95% CI: 2.6 to 34.2, *P* 0.09). Data from nine studies (40, 41, 44, 48, 51-54, 59) contributed to this estimate and the results were very inconsistent across the studies. In particular, one study (54) had a very large increase in LOS associated with third-generation cephalosporin-resistant *K. pneumoniae* (MD 46.6 days, 95% CI: 44.0 to 49.1). The results may be too inconsistent to pool into a single estimate, although all the results indicated an increase in total LOS.
- **ICU admission:** There was a significant increase in the risk of ICU admission for patients with infections caused by third-generation cephalosporin-resistant *K. pneumoniae* (RR 1.39, 95% CI: 1.08 to 1.80, *P* 0.01). Data from three studies (40, 42, 52) contributed to this estimate and the results were somewhat inconsistent across the studies, but all indicated an increased risk. Progression to septic shock: No relationship was found between third-generation cephalosporin-resistant *K. pneumoniae* and progression to septic shock (RR 0.99, 95% CI: 0.64 to 1.53, *P* 0.97). Data from three studies (46, 50, 55) contributed to this estimate and the results were consistent across the studies.
- **Postinfection LOS in hospital:** Two studies (41, 54) indicated a significant increase in postinfection LOS for patients with infections caused by third-generation cephalosporin-resistant *K. pneumoniae* (MD 20.1 days, 95% CI: 18.6 to 21.6 and MD 6.0 days, 95% CI: 2.7 to 9.3 respectively), and in two other studies (49, 60) there was also an increase (MD 18 days and MD 5 days), but the significance could not be assessed as the SDs were not provided. The results were too inconsistent to pool into a single estimate, although all the results indicated an increase in postinfection LOS.



### Carbapenem-resistant *Klebsiella pneumoniae* infections

Published studies comparing carbapenem-resistant and susceptible *K. pneumoniae* infections generally came from high-income countries ( $n = 10$ ). Only three studies were included from upper-middle-income countries, and there were no included studies from low- or lower-middle-income countries. From the included studies (Table A3.6) results were reported on the following health outcomes for infections with carbapenem-resistant *K. pneumoniae*, in summary:

- **All-cause mortality:** There was a significant increase in all-cause mortality for patients with carbapenem-resistant *K. pneumoniae* infections (RR 1.71, 95% CI: 1.35 to 2.18,  $P < 0.0001$ ). Data from 11 studies (63–68, 71–75) contributed to this estimate and the results were somewhat consistent across the studies.
- **Bacterium-attributable mortality:** Only one small study reported bacterium-attributable mortality (67). Results showed that there was no significant increase in attributable mortality for patients with carbapenem-resistant *K. pneumoniae* infections (RR 1.98, 95% CI: 0.61 to 6.43,  $P 0.25$ ).
- **30-day mortality:** There was a significant increase in 30-day mortality for patients with carbapenem-resistant *K. pneumoniae* infections (RR 1.51, 95% CI: 1.19 to 1.91,  $P < 0.0006$ ). Data from three studies (68–70) contributed to this estimate and the results were consistent across the studies.
- **ICU mortality:** One small study (67) reported ICU mortality and found no significant increase in ICU mortality in patients with carbapenem-resistant *K. pneumoniae* infections (RR 1.39, 95% CI: 0.78 to 2.47,  $P 0.26$ ).
- **LOS in hospital:** In two studies (63, 68), there was no significant increase in LOS for patients with carbapenem-resistant *K. pneumoniae* infections (MD 1.0 day, 95% CI: –11.9 to 13.8,  $P 0.88$ ). However, data from the studies that contributed to this estimate were inconsistent. The estimate from one study (68) indicated a non-significant increase in LOS for carbapenem-resistant *K. pneumoniae* patients (MD 6 days, 95% CI: –1.4 to 13.4) and the results of the other study (63) indicated a non-significant decrease in LOS (MD –7.6 days, 95% CI: –23.1 to 7.9). A third study (71) could not be included in the analysis due to missing information (SDs of the mean differences not reported).
- **ICU LOS:** One small study (71) reported ICU LOS and found that patients with carbapenem-resistant *K. pneumoniae* infections had 0.7 days longer stay. However, its significance could not be determined since SDs were not reported.

- **Postinfection LOS:** One small study (70) reported postinfection LOS and found no significant increase in patients with carbapenem-resistant *K. pneumoniae* infections (MD 5 days, 95% CI: –21.7 to 31.7;  $P 0.71$ ).
- **Transfer to other health-care facility:** One small study (71) reported transfer to another health-care facility and found no significant increase in the risk of health-care facility transfer for patients with carbapenem-resistant *K. pneumoniae* infections (RR 0.80, 95% CI: 0.17 to 3.75,  $P 0.78$ ). However, patients enrolled in this study may have come from long-term care facilities at the time of study enrolment, so this result may not be directly attributable to *K. pneumoniae*.
- **Discharge to long-term care:** One small study (71) reported discharge to long-term care and found that there was a significant increase in the risk of long-term care discharge for patients with carbapenem-resistant *K. pneumoniae* infections (RR 2.31, 95% CI: 1.40 to 3.80,  $P 0.001$ ). However, patients enrolled in this study may have come from long-term care facilities at the time of study enrolment, so this result may not be directly attributable to *K. pneumoniae*.

### *Staphylococcus aureus*

#### Methicillin-resistant *Staphylococcus aureus* infections

The literature search identified 17 426 references possibly relevant for the question. Once duplicates were removed, 13 095 remained, of which 616 references were retrieved for full-text review. Ultimately, 147 studies (Table A3.7) met the inclusion criteria for *S. aureus* (60, 76–221).

Almost all of the included studies ( $n = 140$ , 95.2%) were conducted in upper-middle-income countries ( $n = 23$ , 15.6%) or high-income countries ( $n = 117$ , 79.6%). No studies included were conducted in low-income countries, and only two studies in lower-middle-income countries. Five studies included multiple countries, of which most were conducted in high-income countries.

Results were reported on the following health outcomes comparing patients with methicillin-resistant *S. aureus* (MRSA) to those with methicillin-susceptible *S. aureus* (MSSA), in summary:

- **All-cause mortality:** There was a significant increase in all-cause mortality for patients with MRSA infections (RR 1.61, 95% CI: 1.43 to 1.82,  $P < 0.00001$ ). Data from 107 studies contributed to this estimate, and the results were somewhat consistent across the studies. Five studies could

not be included in the effect estimate due to zero deaths reported in both MRSA and MSSA patients (90, 141, 152, 213, 218).

- Bacterium-attributable mortality:** There was a significant increase in bacterium-attributable mortality for patients with MRSA infections (RR 1.64, 95% CI: 1.43 to 1.87,  $P < 0.00001$ ). Data from 46 studies contributed to this estimate and the results were somewhat consistent across the studies. Two small studies (106, 173) not included in the effect estimate reported zero mortality in both the MRSA and MSSA patients enrolled.
- 30-day mortality:** There was a significant increase in 30-day mortality for patients with MRSA infections (RR 1.59, 95% CI: 1.33 to 1.91,  $P < 0.00001$ ). Data from 16 studies (78, 80, 81, 93, 115, 121, 148, 155, 172, 175, 189, 196, 201, 203, 211, 220) contributed to this estimate and the results were somewhat consistent across the studies.
- ICU mortality:** Five studies (76, 112, 171, 196, 209) reported ICU mortality and found that there was a significant increase in ICU mortality in patients with MRSA infections (RR 1.46, 95% CI: 1.23 to 1.74,  $P < 0.0001$ ).
- LOS in hospital:** 50 studies reported total LOS. There was a significant increase in LOS in patients with MRSA (MD 4.65, 95% CI: 2.96 to 6.33,  $P < 0.00001$ ). However, results across studies were somewhat inconsistent. Eight studies (85, 89, 92, 99, 128, 181, 203, 215) could not be included in the analysis due to missing information (SDs not reported).
- Postinfection LOS:** 27 studies reported a statistically significant increase in the mean difference of postinfection LOS (MD 3.12, 95% CI: 1.79 to 4.44,  $P < 0.00001$ ); however, six studies (60, 81, 91, 128, 143, 181) could not be included in the analysis due to missing information (SDs not reported).
- ICU LOS:** 21 studies reported a statistically significant increase in the mean difference in ICU LOS related to MRSA infection (MD 4.00, 95% CI: 2.12 to 5.87,  $P < 0.00001$ ); however, three studies (80, 99, 101) could not be included in the analysis due to missing information (SDs not reported).
- ICU admission:** In 17 studies, there was no significant increase in admission to ICU for patients with MRSA (RR 1.07, 95% CI: 0.92 to 1.25,  $P = 0.36$ ). However, data from the studies that contributed to this estimate were inconsistent. The estimate from one study (195) indicated a significant increase in ICU admission for MRSA patients (RR 2.12, 95% CI: 1.30 to 3.47) and the results of eight other studies (102, 108, 137, 185, 193, 194, 212, 221) indicated a non-significant increase in ICU admission. One study (80) indicated a statistically significant increase in ICU admission for MSSA (RR 0.33, 95% CI: 0.12 to 0.91), and six studies (89, 93, 99, 120, 121, 129) showed non-significant increases in MSSA patients admitted to ICU.
- Progression to septic shock:** There was a significant increase in septic shock for patients with MRSA infections (RR 1.52, 95% CI: 1.24 to 1.88,  $P < 0.0001$ ). Data from 21 studies contributed to this estimate and the results were consistent across the studies.
- Mechanical ventilation:** There was no significant risk of requiring mechanical ventilation in 13 studies (77, 93, 98, 99, 101, 102, 112, 137, 149-151, 164, 196) (RR 1.07, 95% CI: 0.92 to 1.24,  $P = 0.36$ ) that compared MRSA and MSSA patients. However, data from the studies that contributed to this estimate were somewhat inconsistent.
- Attributable readmission:** Six studies (108, 120, 135, 148, 193, 217) reported *S. aureus*-attributable readmissions to hospital following initial discharge. There was no significant increase in attributable readmission in patients with MRSA when compared to those with MSSA (RR 0.91, 95% CI: 0.67 to 1.23,  $P = 0.53$ ).
- Discharge to long-term care:** A single study (217) showed a significant risk increase in discharge to long-term care for patients with MRSA (RR 1.54, 95% CI: 1.02 to 2.34,  $P = 0.04$ ) compared to those with MSSA.
- Discharge to other health-care facility:** A single study (207) showed a significant, more than twofold, risk increase in discharge to long-term care for MRSA (RR 2.78, 95% CI: 1.40 to 5.55,  $P = 0.004$ ) compared to MSSA.

**Table A3.3 Included study characteristics: Third-generation cephalosporin-resistant *Escherichia coli* (n = 25)**

| First author          | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>                  | N resistant | N sensitive | Infection type                                                                                                                                                                  | Duration of follow-up                                         | Ages                                                               | Ref. no. |
|-----------------------|-----------|----------------------------------------------------|--------------------------------------------|-------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------|----------|
| Ortega 2009           | 1991–2007 | Spain                                              | Prospective cohort                         | 211         | 4547        | Inpatients with bacteraemia                                                                                                                                                     | Death or discharge, death at 7 days, 30 days                  | All ages                                                           | (10)     |
| Trecarichi 2009       | 2000–2007 | Italy                                              | Retrospective cohort                       | 26          | 36          | BSI in patients with haematological malignancies                                                                                                                                | 30 days                                                       | ≥15 years                                                          | (7)      |
| Peralta 2007          | 1997–2005 | Spain                                              | Retrospective cohort                       | 31          | 632         | Bacteraemia/BSI – inpatient                                                                                                                                                     | In hospital                                                   | All ages                                                           | (8)      |
| de Kraker 2011        | 2007–2008 | 13 European countries                              | Prospective parallel matched double cohort | 111         | 1110        | BSI, inpatients                                                                                                                                                                 | Hospitalized, 30 days                                         | ≥18 years; all participants were 60+ for resistant and susceptible | (35)     |
| Pena 2008             | 1996–2003 | Spain                                              | Retrospective cohort                       | 100         | 100         | Non-urinary mix of UTI, deep surgical site or intra-abdominal, bacteraemia (primary), bacterial peritonitis in cirrhotic patients, lower respiratory tract                      | NR, assume while in hospital                                  | NR                                                                 | (22)     |
| Nicolas-Chanoine 2012 | 2008–2009 | France                                             | Prospective cohort                         | 152         | 152         | Hospitalized for at least 24 hours with infection – mostly (62%) UTI, other infections were from various deep sites – (for example. blood, surgical and respiratory infections) | NR, assume while in hospital                                  | All ages                                                           | (24)     |
| Ena 2006              | 1999–2004 | Spain                                              | Retrospective cohort                       | 61          | 61          | Inpatients and outpatients with UTI                                                                                                                                             | NR                                                            | NR                                                                 | (34)     |
| Cornejo-Juarez 2012   | 2004–2009 | Mexico                                             | Retrospective cohort                       | 100         | 100         | Haematological malignancies with bacteraemia                                                                                                                                    | 60 days for death, longer for mean survival in alive patients | Unclear                                                            | (36)     |
| Hsieh 2010            | 2005–2006 | Taiwan, China                                      | Retrospective cohort                       | 19          | 385         | Community-onset bacteraemia who visited the emergency department                                                                                                                | 30 days                                                       | All ages                                                           | (30)     |
| Kang 2004             | 1998–2002 | Republic of Korea                                  | Retrospective cohort                       | 5           | 10          | Bacteraemic spontaneous bacterial peritonitis in patients with advanced liver cirrhosis                                                                                         | 30 days                                                       | NR                                                                 | (29)     |
| Tumbarello 2010       | 2006      | Italy                                              | Retrospective cohort                       | 37          | 97          | Inpatients with BSI                                                                                                                                                             | Death or discharge and 21 days mortality                      | >18                                                                | (19)     |
| Gudiol 2010           | 2006–2008 | Spain                                              | Prospective cohort                         | 17          | 118         | Hospitalized cancer/ stem cell transplant patients with >1 episode of bacteraemia                                                                                               | 7 days, 30 days                                               | Adults                                                             | (32)     |

| First author          | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>                                                | N resistant | N sensitive | Infection type                                                                                             | Duration of follow-up                                                              | Ages                                         | Ref. no. |
|-----------------------|-----------|----------------------------------------------------|--------------------------------------------------------------------------|-------------|-------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|----------------------------------------------|----------|
| Apisarnthanarak 2008  | 2003–2004 | Thailand                                           | Cohort                                                                   | 46          | 138         | Community-onset infection inpatients                                                                       | Looked back 1 year for risk factors, NR for mortality, assuming death or discharge | ≥16                                          | (37)     |
| Ho 2002               | 1996–1998 | China                                              | Retrospective cohort                                                     | 49          | 100         | Bacteraemia with clinical features of sepsis                                                               | 30 days mortality                                                                  | NR but average age >73 in cases and controls | (31)     |
| Melzer 2007           | 2003–2005 | United Kingdom                                     | Prospective cohort                                                       | 46          | 308         | Bacteraemia inpatients, community or hospital acquired; large majority (78%) were urinary tract infections | Discharge or death                                                                 | ≥16                                          | (25)     |
| Kang 2011             | 2010–2011 | Republic of Korea                                  | Retrospective cohort                                                     | 108         | 100         | Community-onset <i>E. coli</i> infections                                                                  | 30 days                                                                            | 15+                                          | (27)     |
| Khan 2010             | 2007–2008 | Qatar                                              | Prospective cohort                                                       | 27          | 70          | Bacteraemia, any type of acquisition, hospitalized                                                         | Death or discharge                                                                 | Adults                                       | (26)     |
| Yan 2004              | 1999–2002 | Taiwan, China                                      | Cohort                                                                   | 30          | 60          | <i>E. coli</i> BSI, inpatients                                                                             | NR                                                                                 | ≥18                                          | (18)     |
| Rodriguez-Bano 2010   | 2004–2006 | Spain                                              | Prospective cohort                                                       | 95          | 188         | Community-onset BSI                                                                                        | Until discharge or death                                                           | >14                                          | (21)     |
| Nussbaum 2013         | 2007–2009 | USA (New York)                                     | Retrospective cohort                                                     | 34          | 66          | Hospitalized patients with <i>E. coli</i> bacteraemia                                                      | In hospital                                                                        | NR                                           | (23)     |
| Al-Otaibi 2013        | 2009–2011 | Saudi Arabia                                       | Retrospective cohort                                                     | 113         | 226         | Inpatients and outpatients with UTI                                                                        | NR                                                                                 | All ages                                     | (39)     |
| Kang 2010             | 2008–2009 | Republic of Korea                                  | Retrospective cohort<br>Post hoc analysis of subset of surveillance data | 82          | 783         | Community-onset bacteraemia                                                                                | 30 days                                                                            | NR                                           | (28)     |
| Anunnatsiri 2012      | 2005–2006 | Thailand                                           | Retrospective cohort                                                     | 32          | 113         | Admitted with <i>E. coli</i> septicaemia (ESBL/non-ESBL)                                                   | 72 hours and in hospital                                                           | >15 years                                    | (38)     |
| Garcia-Hernandez 2010 | 2006–2007 | Spain                                              | Cohort                                                                   | 34          | 119         | Admitted patients with <i>E. coli</i> bacteraemia                                                          | 7 days                                                                             | Non-paediatric                               | (33)     |
| Suankratay 2008       | 2004–2006 | Thailand                                           | Prospective cohort                                                       | 35          | 76          | Female patients hospitalized with acute pyelonephritis, community and nosocomial                           | 72 hours and 14 days (but too many lost to report 14 days)                         | >15 years                                    | (20)     |

BSI, bloodstream infection; ESBL, extended spectrum beta-lactamases; NR, not reported; USA, United States of America; UTI, urinary tract infection.

a. For some studies, the original study design may have been a case-control study assessing, for example, risk factors for infection. However, the authors also report for the case-control groups subsequent outcome data and, in this instance, for such outcomes the design would be considered a cohort.

**Table A3.4** Included study characteristics: Fluoroquinolone-resistant *Escherichia coli* (n = 12)

| First author        | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>       | N resistant | N sensitive | Focus/infection type                             | Duration of follow-up                                        | Ages                       | Ref. no. |
|---------------------|-----------|----------------------------------------------------|---------------------------------|-------------|-------------|--------------------------------------------------|--------------------------------------------------------------|----------------------------|----------|
| Cranendonk 2012     | 2008      | Netherlands                                        | Retrospective cohort            | 34          | 34          | Inpatients with bacteraemia                      | During antimicrobial therapy and 6 months                    | All ages                   | (14)     |
| Camins 2011         | 2000–2005 | USA (Mississippi)                                  | Retrospective cohort            | 93          | 93          | Inpatients with bacteraemia                      | NR                                                           | Adults                     | (17)     |
| Pepin 2009          | 2001–2007 | Canada (Québec)                                    | Cohort                          | 93          | 186         | Inpatients and outpatients with UTI              | 48 hours, 30 days                                            | All ages                   | (9)      |
| Ortega 2009         | 1991–2007 | Spain                                              | Prospective surveillance cohort | 1300        | 3458        | Inpatients with bacteraemia                      | Death or discharge                                           | All ages                   | (10)     |
| Trecarichi 2009     | 2000–2007 | Italy                                              | Retrospective cohort            | 39          | 23          | BSI in patients with haematological malignancies | 30 days                                                      | ≥15 years                  | (7)      |
| Peralta 2007        | 1997–2005 | Spain                                              | Retrospective cohort            | 125         | 538         | Bacteraemia or BSI                               | Death or discharge                                           | All ages but 72% >65 years | (8)      |
| Huotari 2003        | 1997–1999 | Finland                                            | Retrospective cohort            | 51          | 102         | Nosocomial, any <i>E. coli</i> infection         | 30 days                                                      | NR                         | (12)     |
| van der Starre 2010 | 2004–2010 | Netherlands                                        | Prospective cohort              | 51          | 102         | Community-onset febrile UTI                      | Unsure                                                       | Adults ≥18 years           | (6)      |
| Cereto 2008         | 2004–2005 | Spain                                              | Prospective cohort              | 18          | 29          | Spontaneous bacterial peritonitis with cirrhosis | During hospitalization and at 3 months                       | Adults                     | (16)     |
| Jeon 2012           | 2005–2008 | Republic of Korea                                  | Observational study             | 39          | 216         | Women with uncomplicated acute pyelonephritis    | 4–7 days after start of therapy, 14–21 days after completion | >15 years                  | (11)     |
| Garau 1999          | 1992–1997 | Spain                                              | Retrospective cohort            | 70          | 502         | Bacteraemia (community and nosocomial)           | Unsure                                                       | All ages                   | (13)     |
| Cheong 2001         | 1993–1998 | Republic of Korea                                  | Retrospective cohort            | 40          | 80          | Bacteraemia                                      | Death or discharge                                           | NR                         | (15)     |

BSI, bloodstream infection; NR, not reported; USA, United States of America; UTI, urinary tract infection.

a. For some studies, the original study design may have been a case-control study assessing, for example, risk factors for infection. However, the authors also report for the case-control groups subsequent outcome data and, in this instance, for such outcomes the design would be considered a cohort.

**Table A3.5** Included study characteristics: Third-generation cephalosporin-resistant *Klebsiella pneumoniae* (n = 24)

| First author        | Years     | Countries, territories and other areas or grouping                         | Study design <sup>a</sup> | N resistant | N sensitive | Infection type                                                                        | Duration of follow-up              | Ages                   | Ref. no. |
|---------------------|-----------|----------------------------------------------------------------------------|---------------------------|-------------|-------------|---------------------------------------------------------------------------------------|------------------------------------|------------------------|----------|
| Lee 2011            | 2002–2009 | Republic of Korea                                                          | Retrospective cohort      | 32          | 192         | Bacteraemia, community + health care associated                                       | 30 days                            | NR, 50% >65            | (53)     |
| Lin 2003            | 2001      | Taiwan, China                                                              | Cohort                    | 43          | 86          | Community + nosocomial infections                                                     | Death or discharge                 | All ages               | (52)     |
| Loh 2006            | 2003–2004 | Malaysia                                                                   | Retrospective cohort      | 47          | 394         | Respiratory tract infections                                                          | Death or discharge                 | ≥12 years              | (51)     |
| Marra 2006          | 1996–2001 | Brazil                                                                     | Retrospective cohort      | 56          | 52          | Nosocomial bacteraemia                                                                | 15 days                            | All ages               | (50)     |
| Mosqueda-Gomez 2008 | 1993–2002 | Mexico                                                                     | Retrospective cohort      | 17          | 104         | BSI                                                                                   | NR                                 | Adults                 | (49)     |
| Song 2009           | 2000–2006 | Republic of Korea                                                          | Retrospective cohort      | 26          | 78          | Advanced liver cirrhosis and spontaneous bacterial peritonitis                        | 30 days                            | NR                     | (43)     |
| Rebuck 2000         | 1997–1999 | USA                                                                        | Retrospective cohort      | 20          | 16          | Hospitalized children who received liver transplants, intestinal transplants, or both | Death or discharge (max. 316 days) | Children               | (44)     |
| Kang 2006           | 1998–2002 | Republic of Korea                                                          | Retrospective cohort      | 69          | 308         | Nosocomial + community bacteraemia                                                    | 30 days                            | >16 years              | (56)     |
| Huang 2007          | 2000–2002 | China                                                                      | Retrospective cohort      | 19          | 12          | Neonates nosocomial infection                                                         | 30 days                            | Neonates               | (57)     |
| Paterson 2004       | 1996–1997 | Argentina, Australia, Belgium, Taiwan, China, South Africa, Turkey and USA | Prospective cohort        | 78          | 175         | Nosocomial bacteraemia                                                                | 1 month                            | >16 years              | (47)     |
| Pillay 1998         | 1995–1996 | South Africa                                                               | Prospective cohort        | 18          | 15          | Nosocomial infection outbreak                                                         | NR                                 | Neonates >48 hours old | (45)     |
| BARTF 2002          | 1999      | USA (Brooklyn)                                                             | Retrospective cohort      | 9           | 9           | Nosocomial – UTI, respiratory tract infection, bacteraemia                            | NR                                 | Adults                 | (60)     |
| Tumbarello 2005     | 1999–2003 | Italy                                                                      | Retrospective cohort      | 48          | 99          | Nosocomial + community bacteraemia                                                    | 21 days                            | NR                     | (41)     |
| Gomez 2006          | 1998      | Brazil                                                                     | Retrospective cohort      | 68          | 75          | Nosocomial infection                                                                  | 21 days                            | >18 years              | (58)     |
| Demirdag 2010       | 2004–2005 | Turkey                                                                     | Retrospective cohort      | 52          | 52          | Nosocomial + community infection                                                      | NR                                 | NR                     | (59)     |
| Kuo 2007            | 1992–2000 | Taiwan, China                                                              | Retrospective cohort      | 54          | 54          | Children with <i>K. pneumoniae</i> infections (community + nosocomial)                | Death or discharge                 | Children               | (54)     |
| Kang 2004           | 2006–2009 | Republic of Korea                                                          | Retrospective cohort      | 60          | 60          | BSI (community + nosocomial)                                                          | 30 days                            | NR                     | (29)     |
| Tuon 2010           | 2006–2009 | Brazil                                                                     | Retrospective cohort      | 63          | 41          | Bacteraemia                                                                           | 30 days                            | >12 years              | (40)     |

| First author  | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup> | N resistant | N sensitive | Infection type                                                     | Duration of follow-up | Ages          | Ref. no. |
|---------------|-----------|----------------------------------------------------|---------------------------|-------------|-------------|--------------------------------------------------------------------|-----------------------|---------------|----------|
| Kang 2004     | 1998–2002 | Republic of Korea                                  | Retrospective cohort      | 10          | 20          | Advanced liver cirrhosis and bacteraemia                           | 30 days               | Likely adults | (55)     |
| Chiu 2005     | 2001      | Taiwan, China                                      | Retrospective cohort      | 15          | 16          | Nosocomial enterobacterial infections in neonatal ICU              | NR                    | Neonates      | (61)     |
| Ariffin 1999  | 1996–1997 | (Malaysia (Kuala Lumpur)                           | Prospective cohort        | 16          | 15          | Febrile neutropenic children with <i>K. pneumoniae</i> bacteraemia | NR                    | ≤12 years     | (62)     |
| Pena 2001     | 1993–1995 | Spain                                              | Prospective cohort        | 45          | 42          | Nosocomial bacteraemia, outbreak                                   | NR                    | Adults        | (46)     |
| Szilagyi 2009 | 2005–2008 | Hungary                                            | Retrospective cohort      | 100         | 100         | Nosocomial bacteraemia                                             | NR                    | NR            | (42)     |
| Panhotra 2004 | 2001–2003 | Saudi Arabia                                       | Retrospective cohort      | 10          | 16          | Nosocomial bacteraemia                                             | NR                    | 10–98 years   | (48)     |

BSI, bloodstream infection; ICU, intensive care unit; NR, not reported; USA, United States of America; UTI, urinary tract infection.

a. For some studies, the original study design may have been a case-control study assessing, for example, risk factors for infection. However, the authors also report for the case-control groups subsequent outcome data and, in this instance, for such outcomes the design would be considered a cohort.

**Table A3.6** Included study characteristics: Carbapenem-resistant *Klebsiella pneumoniae* (n = 12)

| First author  | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup> | N resistant | N sensitive | Infection type                                 | Duration of follow-up            | Ages             | Ref. no. |
|---------------|-----------|----------------------------------------------------|---------------------------|-------------|-------------|------------------------------------------------|----------------------------------|------------------|----------|
| Liu 2011      | 2007–2009 | Taiwan, China                                      | Cohort                    | 25          | 50          | Bacteraemic inpatients                         | 14 days, 28 days, in hospital    | NR               | (68)     |
| Correa 2013   | 2006–2008 | Brazil                                             | Cohort                    | 20          | 40          | Health-care-associated infections              | NR – assuming death or discharge | All ages         | (75)     |
| Falagas 2007  | 2000–2006 | Greece                                             | Cohort                    | 53          | 53          | Inpatients with infections                     | NR – assuming death or discharge | NR               | (72)     |
| Mouloudi 2010 | 2007–2008 | Greece                                             | Cohort                    | 37          | 22          | BSI in ICU patients                            | NR – assuming death or discharge | Adults           | (67)     |
| Patel 2008    | 2004–2006 | USA (New York City)                                | Cohort                    | 99          | 276         | Inpatients with invasive infection             | In hospital                      | Adults           | (66)     |
| Daikos 2006   | 2003–2004 | Greece                                             | Retrospective cohort      | 56          | 56          | BSI in hospitalized patients                   | 14 days                          | NR               | (74)     |
| Daikos 2009   | 2004–2006 | Greece                                             | Prospective cohort        | 14          | 148         | BSI in hospitalized patients                   | Discharge or death               | NR               | (73)     |
| Gaviria 2012  | 2009–2011 | USA (West Virginia)                                | Cohort                    | 19          | 38          | General inpatients with infection              | NR – assuming death or discharge | NR               | (71)     |
| Raviv 2012    | 2004–2007 | Israel                                             | Retrospective cohort      | 11          | 29          | Lung transplant patients who acquire infection | 1, 3, 6, 12 months               | Adults ≥18 years | (65)     |
| Shilo 2012    | 2006–2009 | Israel (Jerusalem)                                 | Cohort                    | 135         | 127         | Bacteriuria in hospitalized patients           | Death or discharge               | <14 years        | (63)     |
| Schwaber 2008 | 2003–2006 | Israel                                             | Cohort                    | 48          | 56          | Inpatients with infection                      | In hospital                      | Adults           | (64)     |
| Hussein 2012  | 2006–2008 | Israel                                             | Retrospective cohort      | 103         | 214         | Inpatients with positive blood cultures        | 30 days                          | Adults ≥18       | (70)     |
| Lee 2011      | 2008–2009 | China                                              | Retrospective cohort      | 41          | 62          | Patients with BSI                              | In hospital                      | NR               | (69)     |

BSI, bloodstream infection; ICU, intensive care unit; NR, not reported; USA, United States of America.

a. For some studies, the original study design may have been a case-control study assessing, for example, risk factors for infection. However, the authors also report for the case-control groups subsequent outcome data and, in this instance, for such outcomes the design would be considered a cohort.



**Table A3.7 Included study characteristics: Methicillin-resistant *Staphylococcus aureus* (n = 147)**

| First author          | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>    | N resistant | N sensitive | Infection type                                                                                | Ages         | Ref. no. |
|-----------------------|-----------|----------------------------------------------------|------------------------------|-------------|-------------|-----------------------------------------------------------------------------------------------|--------------|----------|
| Abramson 1999         | 1993–1995 | USA                                                | Retrospective cohort         | 8           | 11          | Inpatient BSI                                                                                 | >18 years    | (221)    |
| Allard 2008           | 1991–2005 | Canada                                             | Retrospective cohort         | 69          | 746         | Bacteraemia                                                                                   | >18 years    | (220)    |
| Al-Nammari 2007       | 2000–2005 | United Kingdom                                     | Retrospective cohort         | 15          | 43          | Haematogenous septic arthritis                                                                | >16 years    | (219)    |
| Al-Otaibi 2010        | 2005–2008 | Saudi Arabia                                       | Retrospective cohort         | 85          | 200         | Children with invasive community-acquired MRSA; outpatients and some required hospitalization | 0–18 years   | (218)    |
| Anderson 2009         | 1998–2003 | USA                                                | Matched outcomes study       | 150         | 128         | Surgical site infection                                                                       | NR           | (217)    |
| Arnold 2006           | 2000–2004 | USA                                                | Cohort                       | 47          | 21          | Paediatric acute haematogenous osteomyelitis and septic arthritis                             | Children     | (216)    |
| Austin 2003           | 1994–1995 | Canada                                             | Cohort                       | 50          | 50          | Inpatient bacteraemia                                                                         | NR           | (215)    |
| Bader 2006            | 2003–2004 | USA                                                | Retrospective cohort         | 74          | 58          | SA bacteraemia                                                                                | Older adults | (214)    |
| Baggett 2003          | 1998–2000 | USA (Alaska, small rural setting)                  | Retrospective cohort         | 172         | 60          | General outpatients and inpatients with SA skin infections                                    | NR           | (213)    |
| Baraboutis 2011       | 1997–2001 | USA                                                | Cohort                       | 127         | 170         | Health-care-associated infections                                                             | NR           | (212)    |
| Bassetti 2011         | 2007      | Italy                                              | Case-control + cohort        | 89          | 76          | Health-care-associated and community-acquired bacteraemia                                     | NR           | (211)    |
| Bastug 2012           | 2006–2009 | Turkey                                             | Retrospective cohort         | 102         | 74          | N bacteraemia                                                                                 | ≥18          | (210)    |
| Ben-David 2009        | 2000–2003 | USA                                                | Retrospective cohort         | 95          | 87          | N bacteraemia                                                                                 | NR           | (209)    |
| Blot 2002             | 1992–1998 | Belgium                                            | Retrospective cohort         | 47          | 38          | Critically ill patients with bacteraemia                                                      | Adults       | (208)    |
| Burke 2009            | 2001–2006 | USA (California)                                   | Retrospective cohort         | 29          | 121         | Inpatient children with SA bacteraemia                                                        | <18 years    | (207)    |
| Capitano 2003         | 1996–2000 | USA                                                | Retrospective cohort         | 41          | 49          | SA infections in long-term care facility                                                      | Elderly      | (206)    |
| Carey 2010            | 2000–2007 | USA (New York)                                     | Retrospective cohort (chart) | 49          | 123         | Nosocomial ICU patients with MRSA/MSSA infections (BSI or SSTIs)                              | Infants      | (205)    |
| Carrillo-Marquez 2010 | 2001–2007 | USA (Texas)                                        | Prospective cohort           | 29          | 83          | Children with SA-catheter-related bacteraemia                                                 | NR           | (204)    |
| Castillo 2012         | 2005–2008 | Colombia                                           | Retrospective cohort         | 186         | 186         | Critically ill inpatients with SA bacteraemia                                                 | ≥16 years    | (203)    |

| First author         | Years                | Countries, territories and other areas or grouping | Study design <sup>a</sup>    | N resistant | N sensitive | Infection type                                                                                            | Ages             | Ref. no. |
|----------------------|----------------------|----------------------------------------------------|------------------------------|-------------|-------------|-----------------------------------------------------------------------------------------------------------|------------------|----------|
| Chan 2012            | 2006–2010            | USA                                                | Cohort                       | 7090        | 8333        | Haemodialysis end-stage renal disease outpatients with SA bacteraemia                                     | NR               | (202)    |
| Chang 2003           | 1994–1996            | USA                                                | Prospective cohort           | 20          | 44          | General SA bacteraemia patients with a subgroup who develop endocarditis                                  | NR               | (201)    |
| Changchien 2011      | 2004–2008            | Taiwan, China                                      | Cohort                       | 49          | 42          | Postoperative patients with necrotizing fasciitis                                                         | NR               | (200)    |
| Chen 2010            | 2001–2007            | Taiwan, China                                      | Cohort                       | 244         | 500         | Community-onset bacteraemia                                                                               | >15 years        | (199)    |
| Clancy 2005          | 2003                 | USA                                                | Cohort                       | 57          | 136         | Community-acquired SA infection                                                                           | All ages         | (198)    |
| Cofsky (BARTIF) 2002 | 1999                 | USA                                                | Cohort                       | 14          | 14          | Nosocomial infections                                                                                     | NR               | (60)     |
| Combes 2004          | Unclear              | France                                             | Cohort                       | 74          | 97          | SA ventilator-associated pneumonia patients with appropriate initial antibiotic therapy; all ICU patients | NR               | (197)    |
| Combes 2004          | 1989–2001            | France                                             | Cohort                       | 73          | 145         | SA poststernotomy mediastinitis patients (surgical) treated in ICU                                        | NR               | (196)    |
| Conterno 1998        | 1991–1992            | Brazil                                             | Cohort                       | 90          | 46          | Bacteraemia                                                                                               | >14 years        | (195)    |
| Cosgrove             | 1997–2000            | USA                                                | Cohort                       | 96          | 252         | Inpatient bacteraemia                                                                                     | NR               | (194)    |
| Cowie 2005           | 2001                 | Canada                                             | Retrospective cohort         | 22          | 15          | Nosocomial infections in vascular surgery patients                                                        | NR               | (193)    |
| Cunney 1996          | 1991–1993            | Ireland                                            | Cohort                       | 18          | 92          | Nosocomial and community-acquired septicaemia                                                             | NR               | (192)    |
| Das 2007             | 2001–2002            | United Kingdom                                     | Prospective cohort           | 84          | 56          | Bacteraemia                                                                                               | >18 years        | (191)    |
| Davis 2007           | 2003–2005            | USA                                                | Cohort                       | 102         | 102         | Patients with community-associated SA infections                                                          | NR               | (190)    |
| de Kraker 2011       | 2007–2008            | 13 European countries                              | Matched parallel cohort      | 248         | 618         | Inpatients with laboratory-confirmed diagnosis of SA BSI                                                  | >18 years        | (189)    |
| de Oliveira 2002     | 1990–1991, 1995–1996 | Brazil                                             | Cohort                       | 159         | 92          | Bacteraemia                                                                                               | >14 years        | (188)    |
| Engemann 2003        | 1994–2000            | USA                                                | Cohort                       | 121         | 165         | Surgical site infection                                                                                   | NR               | (187)    |
| Erdem 2010           | 1996–2007            | USA (Hawaii)                                       | Cohort                       | 26          | 14          | Hospitalized children with community-acquired SA pneumonia                                                | NR               | (186)    |
| Erdem 2010           | 1996–2007            | USA                                                | Retrospective cohort (chart) | 15          | 47          | Paediatric osteomyelitis                                                                                  | 1 month–18 years | (185)    |

| First author    | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>                   | N resistant | N sensitive | Infection type                               | Ages      | Ref. no. |
|-----------------|-----------|----------------------------------------------------|---------------------------------------------|-------------|-------------|----------------------------------------------|-----------|----------|
| Ernst 2005      | 1997–2001 | USA                                                | Case-control, control with cohort           | 21          | 21          | Nosocomial bacteraemia                       | NR        | (184)    |
| Filice 2010     | 2004–2006 | USA                                                | Retrospective cohort                        | 335         | 390         | SA infection                                 | NR        | (183)    |
| Fortunov 2006   | 2002–2004 | USA                                                | Retrospective cohort                        | 61          | 28          | Community-acquired infections in neonates    | <30 days  | (182)    |
| French 1990     | 1984–1988 | Hong Kong SAR                                      | Cohort                                      | 74          | 80          | Nosocomial bacteraemia                       | NR        | (181)    |
| Ganga 2009      | 2005–2006 | USA                                                | Cohort                                      | 163         | 90          | Bacteraemia                                  | Adults    | (180)    |
| Gerber 2009     | 2002–2007 | USA                                                | Retrospective cohort                        | 29 309      | 28 485      | SA infection in hospitalized children        | <18 years | (179)    |
| Gonzalez 1999   | 1990–1995 | Spain                                              | Prospective cohort                          | 32          | 54          | Bacteraemic pneumonia                        | NR        | (178)    |
| Graffunder 2002 | 1997–1999 | USA                                                | Cohort                                      | 121         | 123         | Nosocomial SA infection                      | Adults    | (177)    |
| Greiner 2007    | 1999–2005 | Germany                                            | Retrospective cohort                        | 28          | 81          | BSI in patients with end-stage renal disease | NR        | (176)    |
| Guilarde 2006   | 2000–2001 | Brazil                                             | Cohort                                      | 61          | 50          | BSI                                          | >1 year   | (175)    |
| Haessler 2008   | 1998–2000 | USA                                                | Retrospective cohort                        | 118         | 118         | SA infections – inpatients and outpatients   | >18 years | (174)    |
| Hakim 2007      | 2000–2004 | USA                                                | Retrospective cohort (chart)                | 14          | 22          | Bacteraemia in children                      | <18 years | (173)    |
| Han 2012        | 2007–2009 | USA                                                | Retrospective cohort                        | 190         | 202         | Adult inpatients with SA bacteraemia         | Adults    | (172)    |
| Hanberger 2011  | 2007      | 75 countries                                       | Cohort                                      | 494         | 505         | Infection in the ICU                         | NR        | (171)    |
| Harbarth 1998   | 1994–1995 | Switzerland                                        | Retrospective cohort + case-control         | 39          | 145         | Bacteraemia                                  | NR        | (170)    |
| Harbarth 1998   | 1994–1996 | Switzerland                                        | Matched case-control from cohort population | 38          | 38          | Bacteraemia                                  | NR        | (170)    |
| Hawkins 2007    | 2001–2004 | USA                                                | Cohort                                      | 120         | 116         | Hospitalized patients with bacteraemia       | NR        | (169)    |
| Hawkshead 2009  | 1993–2005 | USA                                                | Unclear                                     | 21          | 27          | Paediatric osteomyelitis                     | Children  | (168)    |
| Heo 2007        | 2000–2005 | Republic of Korea – Seoul                          | Retrospective case-control and cohort       | 63          | 168         | Bacteraemia in emergency department          | NR        | (167)    |
| Hershow 1992    | 1989      | USA                                                | Retrospective cohort                        | 22          | 22          | Adults with nosocomial SA infection          | ≥18       | (166)    |
| Hill 2008       | 2000–2006 | Belgium                                            | Cohort                                      | 16          | 56          | Infective endocarditis                       | NR        | (165)    |

| First author     | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>         | N resistant     | N sensitive | Infection type                                                                   | Ages              | Ref. no. |
|------------------|-----------|----------------------------------------------------|-----------------------------------|-----------------|-------------|----------------------------------------------------------------------------------|-------------------|----------|
| Ho 2009          | 1997–2007 | Australia                                          | Cohort                            | 21              | 60          | Bacteraemia in critically ill patients                                           | NR                | (164)    |
| Hsu 2004         | 1995–2002 | Taiwan, China                                      | Unclear                           | 29              | 28          | Infective endocarditis                                                           | NR                | (163)    |
| Hsu 2007         | 1995–2005 | Taiwan, China                                      | Unclear                           | 48              | 75          | Infective endocarditis                                                           | All ages          | (162)    |
| Huang 2008       | 2003–2004 | USA                                                | Cohort                            | 127             | 127         | Community-associated SA infection                                                | NR                | (161)    |
| Hulten 2010      | 2001–2007 | USA                                                | Retrospective cohort              | 95              | 147         | Nosocomial paediatric infection                                                  | Children          | (160)    |
| Isaacs 2004      | 1992–1999 | Australia                                          | Prospective surveillance cohort   | 65              | 223         | SA sepsis in neonatal nurseries                                                  | Newborn           | (159)    |
| Jimenez 2013     | 2008–2010 | Colombia                                           | Cross-sectional                   | 539             | 271         | SA infections                                                                    | 16–60 years       | (158)    |
| Joo 2012         | 2007–2009 | Republic of Korea (Seoul)                          | Case-control and cohort           | 84              | 84          | Community-onset SA infection                                                     | NR                | (157)    |
| Kalwaje 2012     | 1 year    | India                                              | Cohort                            | 38              | 32          | Bacteraemia                                                                      | NR                | (156)    |
| Kang 2010        | 2007–2006 | Nine Asian countries                               | Cohort                            | 2090            | 2859        | Asian Network for Surveillance of Resistant Pathogens – SA infections            | All ages          | (155)    |
| Khatib 2006      | 2002–2003 | USA                                                | Observational                     | 174             | 168         | Adult inpatients with bacteraemia                                                | >18 years         | (154)    |
| Kim 2003         | 1998–2001 | Republic of Korea (Seoul)                          | Retrospective cohort              | 127             | 111         | Bacteraemia                                                                      | NR                | (153)    |
| Kini 2013        | 2004–2008 | India                                              | Retrospective cohort (chart)      | 41              | 33          | Paediatric bone and joint infections                                             | 8 months–17 years | (152)    |
| Kopp 2004        | 1999–2000 | USA                                                | Retrospective cohort              | 36              | 36          | SA infections                                                                    | >2 years          | (151)    |
| Kuint 2007       | 1993–2003 | Israel                                             | Cohort                            | 11 <sup>b</sup> | 12          | Bacteraemia in neonatal ICU                                                      | Neonates          | (150)    |
| Kuint 2007       | 1993–2004 | Israel                                             | Cohort                            | 20 <sup>c</sup> | 12          | Bacteraemia in neonatal ICU                                                      | Neonates          | (150)    |
| Kuo 2007         | 2000–2005 | Taiwan, China                                      | Retrospective cohort (chart)      | 16              | 6           | Endocarditis in haemodialysis patients                                           | NR                | (149)    |
| Lawes 2012       | 2006–2010 | United Kingdom (Scotland)                          | Retrospective cohort              | 208             | 659         | All inpatients – assessing impact of screening for MRSA bacteraemia              | NR                | (148)    |
| Lepelletier 2004 | 1994–2001 | France                                             | Unmatched case-control and cohort | 24              | 64          | ICU patients with nosocomial SA infections (respiratory, bacteraemia or urinary) | All ages          | (147)    |
| Lesens 2003      | 2001–2002 | France                                             | Cohort                            | 53              | 113         | Bacteraemia in adults                                                            | >18 years         | (146)    |
| Lesse 2006       | 1997–2003 | USA (New York)                                     | Cohort                            | 15              | 24          | Nursing home residents with SA bacteraemia                                       | NR                | (145)    |

| First author          | Years                  | Countries, territories and other areas or grouping | Study design <sup>a</sup>   | N resistant | N sensitive | Infection type                                                                         | Ages             | Ref. no. |
|-----------------------|------------------------|----------------------------------------------------|-----------------------------|-------------|-------------|----------------------------------------------------------------------------------------|------------------|----------|
| Lewis 1985            | 1980–1981              | USA (Michigan)                                     | Cohort                      | 28          | 28          | Community-acquired SA bacteraemia patients with history of parental drug use and abuse | NR               | (144)    |
| Lodise 2005           | 1999–2001              | USA (Michigan)                                     | Cohort                      | 170         | 183         | Inpatients with SA bacterium                                                           | NR               | (143)    |
| Manzur 2007           | 1999–2003              | Spain                                              | Cohort                      | 50          | 98          | Inpatients with SA BSI                                                                 | NR               | (142)    |
| Martinez-Aguilar 2003 | 2000; 2001–2002        | USA (Texas)                                        | Cohort                      | 46          | 53          | Children with community-acquired SA infection                                          | NR               | (140)    |
| Martinez-Aguilar 2004 | 2000–2002 <sup>d</sup> | USA (Texas)                                        | Cohort                      | 31          | 28          | Inpatient children with community-acquired SA and musculoskeletal infections           | NR               | (141)    |
| Marty 1993            | 1982–1988              | France                                             | Case-control and cohort     | 14          | 14          | Cancer inpatients with SA bacteraemia                                                  | All ages         | (139)    |
| McHugh 2004           | 1997–1999              | USA (Washington)                                   | Cohort                      | 20          | 40          | Inpatients with SA BSI confirmed by culture                                            | NR               | (138)    |
| Mekontso-Dessap 2001  | 1996–2000              | France                                             | Cohort                      | 15          | 26          | Surgical patients developing SA poststernotomy mediastinitis                           | NR               | (137)    |
| Melzer 2003           | 1995–2000              | United Kingdom (England)                           | Cohort                      | 433         | 382         | Inpatients and outpatients with nosocomial bacteraemia                                 | Adults ≥16 years | (136)    |
| Miller 2007           | 2004                   | USA (California)                                   | Prospective cohort          | 70          | 47          | Hospitalized patients discharged after community-acquired SA skin infection            | NR               | (135)    |
| Mishaan 2005          | 2001–2003              | USA (Texas)                                        | Cohort                      | 68          | 49          | Paediatric patients with community-acquired SA infections and corresponding isolates   | NR               | (134)    |
| Morikawa 2012         | 2004–2009              | Japan                                              | Cohort                      | 68          | 83          | Patients with acute SA pneumonia with thin-section chest CT exams                      | NR               | (133)    |
| Naves 2012            | 2006–2008              | Brazil                                             | Cohort                      | 29          | 22          | Non-ICU patients with SA BSI                                                           | NR               | (132)    |
| Nickerson 2006        | 2003–2004              | Thailand                                           | Cohort                      | 36          | 121         | Inpatients with SA bacteraemia (positive blood culture for SA)                         | NR               | (130)    |
| Nickerson 2009        | 2006–2007              | Thailand                                           | Cohort                      | 27          | 71          | SA bacteraemia patients                                                                | All ages         | (131)    |
| Ochoa 2005            | 2000–2001; 2002–2003   | USA (Texas)                                        | Cohort                      | 159         | 80          | Paediatric inpatients with SA infections                                               | NR               | (129)    |
| O’Kane 1998           | 1993                   | Australia                                          | Retrospective cohort (case) | 32          | 73          | SA bacteraemia patients                                                                | NR               | (128)    |
| Osmon 2004            | 2001–2002              | USA (Missouri)                                     | Prospective cohort          | 148         | 117         | Hospitalized patients with SA bacteraemia                                              | NR               | (127)    |

| First author       | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup> | N resistant      | N sensitive      | Infection type                                                                                         | Ages             | Ref. no.   |
|--------------------|-----------|----------------------------------------------------|---------------------------|------------------|------------------|--------------------------------------------------------------------------------------------------------|------------------|------------|
| Ott 2010           | 2005–2007 | Germany                                            | Cohort                    | 41               | 41               | Inpatients with nosocomial SA pneumonia                                                                | NR               | (126)      |
| Park 2011          | 2003–2008 | Republic of Korea                                  | Cohort                    | 53               | 53               | Inpatients with SA bacteraemia                                                                         | NR               | (125)      |
| Parvizi 2010       | 1998–2008 | USA (Pennsylvania)                                 | Cohort                    | 231              | 160              | Surgical patients with periprosthetic joint infection caused by SA                                     | NR               | (124)      |
| Pasticci 2011      | 1988–2009 | Italy                                              | Cohort                    | 13               | 49               | Infective SA endocarditis                                                                              | NR               | (123)      |
| Perovic 2006       | 1999–2002 | South Africa                                       | Cohort                    | 105              | 344              | Inpatients with SA bacteraemia                                                                         | Adults           | (122)      |
| Ponce-de-Leon 2010 | 2003–2007 | Mexico                                             | Cohort                    | 79               | 93               | Inpatients with SA BSI                                                                                 | Adults ≥16 years | (121)      |
| Popovich 2010      | 2000–2007 | USA (Illinois)                                     | Cohort                    | 162              | 91               | HIV-infected patients with community-acquired SSTIs                                                    | NR               | (120)      |
| Priest 2005        | 1994–2000 | USA (North Carolina)                               | Cohort                    | 11               | 24               | Inpatients with SA haematogenous vertebral osteomyelitis                                               | NR               | (119)      |
| Pujol 1996         | 1991–1992 | Spain                                              | Cohort                    | 24               | 8                | ICU patients with SA nasal carriage progressing to bacteraemia                                         | NR               | (117)      |
| Pujol 1998         | 1990–1994 | Spain                                              | Cohort                    | 41 <sup>e</sup>  | 98               | Mechanically ventilated ICU patients who developed SA pneumonia                                        | NR               | (118)      |
| Quilty 2009        | 2004–2007 | Australia                                          | Cohort                    | 5                | 5                | Chemotherapy-induced febrile neutropenia patients with SA sepsis                                       | NR               | (116)      |
| Rahikka 2011       | 2002–2010 | Finland                                            | Cohort                    | 51               | 51               | Inpatients with SA bacteraemia                                                                         | NR               | (115)      |
| Rana 2012          | 2001–2008 | USA (Ohio)                                         | Cohort                    | 22               | 12               | Infants with positive SA blood culture                                                                 | NR               | (114)      |
| Reed 2005          | 1996–2001 | USA (North Carolina)                               | Cohort                    | 54               | 89               | Haemodialysis inpatients with end-stage renal disease and SA bacteraemia                               | NR               | (113)      |
| Rello 1994         | 1991–1993 | Spain                                              | Cohort                    | 11               | 38               | Mechanically ventilated patients who developed SA nosocomial infections in the lower respiratory tract | NR               | (111)      |
| Rello 2012         | Unclear   | Unclear                                            | Cohort                    | E = 15;<br>L = 5 | E = 30;<br>L = 6 | ICU patients with hospital-acquired pneumonia or ventilator-associated pneumonia from SA               | NR               | (112)      |
| Reshad 1994        | 1983–1991 | Japan                                              | Cohort                    | 46               | 48               | Patients with SA septicaemia                                                                           | NR               | (110)      |
| Romero-Vivas 1995  | 1990–1993 | Spain                                              | Cohort                    | 84               | 100              | N SA bacteraemia patients                                                                              | NR               | (108, 109) |

| First author         | Years     | Countries, territories and other areas or grouping | Study design <sup>a</sup>                                                          | N resistant     | N sensitive     | Infection type                                                             | Ages             | Ref. no. |
|----------------------|-----------|----------------------------------------------------|------------------------------------------------------------------------------------|-----------------|-----------------|----------------------------------------------------------------------------|------------------|----------|
| Rubio-Terres 2010    | 2005      | Spain                                              | Cohort                                                                             | 121             | 245             | SA bacteraemia patients                                                    | Adults ≥18 years | (108)    |
| Saavedra-Lozano 2008 | 1999–2003 | USA (Texas)                                        | Cohort                                                                             | 36              | 72              | Children inpatients with acute SA osteomyelitis                            | NR               | (107)    |
| Salgado 2007         | 1998–2004 | USA (South Carolina)                               | Cohort                                                                             | 33 <sup>f</sup> | 12 <sup>g</sup> | Patients with prosthetic joint infection from SA                           | NR               | (106)    |
| Selvey 2000          | 1992–1997 | Australia                                          | Cohort                                                                             | 188             | 316             | Inpatients with nosocomial SA bacteraemia                                  | NR               | (105)    |
| Shane 2012           | 2006–2008 | USA (Maryland)                                     | Cohort                                                                             | 88              | 228             | Very low birth weight infants with SA bacteraemia and/or meningitis        | NR               | (104)    |
| Shorr 2006           | Unclear   | France                                             | Retrospective analysis of pooled, patient-level data from multiple clinical trials | 38              | 69              | ICU patients with SA ventilator-associated pneumonia                       | NR               | (101)    |
| Shorr 2006           | 2002–2003 | USA                                                | Cohort                                                                             | 95              | 59              | Patients with early and late SA-related ventilator-associated pneumonia    | NR               | (103)    |
| Shorr 2010           | 2005–2008 | USA (Michigan)                                     | Cohort                                                                             | 87              | 55              | Patients with SA health-care-associated pneumonia                          | NR               | (102)    |
| Shurland 2007        | 1995–2003 | USA (Maryland)                                     | Retrospective cohort                                                               | 193             | 245             | Patients (majority veterans) with SA infections complicated by bacteraemia | Adults           | (100)    |
| Sicot 2013           | 1986–2010 | France                                             | Cohort                                                                             | 29              | 104             | Inpatients with PVL-positive SA community-acquired necrotizing pneumonia   | NR               | (99)     |
| Soriano 2000         | 1991–1998 | Spain                                              | Cohort                                                                             | 225             | 683             | Patients with monocrobial SA bacteraemia                                   | NR               | (98)     |
| Spindel 1995         | 1987–1991 | USA (Oregon)                                       | Cohort                                                                             | 28              | 40              | Veterans' affairs nursing home care unit residents with SA infections      | NR               | (97)     |
| Takayama 2010        | 1990–2006 | Japan                                              | Cohort                                                                             | 10              | 23              | Patients with definite infective endocarditis                              | NR               | (96)     |
| Talon 2002           | 1997–1998 | France                                             | Prospective cohort                                                                 | 30              | 69              | Inpatients with SA bacteraemia                                             | NR               | (95)     |
| Tam 1988             | 1976–1985 | Hong Kong SAR                                      | Cohort                                                                             | 29              | 13              | Neonates with severe SA infection                                          | NR               | (94)     |
| Taneja 2010          | 2005–2008 | USA (Michigan)                                     | Cohort                                                                             | 55              | 73              | Inpatients with SA community-acquired pneumonia                            | NR               | (93)     |
| Teterycz 2010        | 1996–2008 | Switzerland                                        | Retrospective cohort                                                               | 44              | 58              | Patients with orthopaedic implant infections                               | NR               | (92)     |
| Theodorou 2013       | 1989–2009 | Germany                                            | Cohort                                                                             | 33              | 41              | Burn patients with SA bacteraemia                                          | NR               | (91)     |
| Thomason 2007        | 2001–2005 | USA (Texas)                                        | Cohort                                                                             | 66              | 57              | Children with SA neck abscesses                                            | NR               | (90)     |

| First author         | Years                  | Countries, territories and other areas or grouping | Study design <sup>a</sup> | N resistant | N sensitive | Infection type                                                                            | Ages             | Ref. no. |
|----------------------|------------------------|----------------------------------------------------|---------------------------|-------------|-------------|-------------------------------------------------------------------------------------------|------------------|----------|
| Tong 2009            | 2006–2007              | Australia                                          | Case-control and cohort   | 239         | 478         | Patients with SA infections (combined with colonized – present data for both populations) | NR               | (89)     |
| Traverso 2010        | 2006–2008              | Argentina                                          | Cohort                    | 17          | 22          | Hospitalized patients with bacteraemia                                                    | NR               | (88)     |
| Trividic-Rumeau 2003 | 2000–2001              | France                                             | Cohort                    | 21          | 22          | Hospitalized patients with leg ulcers or foot wounds                                      | NR               | (87)     |
| Truffault 2000       | 1996–1997              | France                                             | Cohort                    | 39          | 20          | ICU patients admitted for at least 48 hours with SA infection                             | NR               | (86)     |
| Tsai 2011            | 2003–2009              | Taiwan, China                                      | Cohort                    | 29          | 26          | Patients with necrotizing fasciitis caused by SA or <i>Vibrio vulnificus</i>              | NR               | (85)     |
| Tumbarello 2002      | 1991–2000              | Italy                                              | Cohort                    | 41          | 88          | Bacteraemia in HIV-infected patients                                                      | >18 years        | (84)     |
| Viallon 2007         | 2003–2004              | France                                             | Retrospective cohort      | 93          | 145         | SA infections in patients admitted to emergency department                                | NR               | (83)     |
| Wang CY 2012         | 2007                   | Taiwan, China                                      | Cohort                    | 10          | 7           | SA in end-stage renal disease                                                             | NR               | (82)     |
| Wang FD 2008         | 1990–2004              | Taiwan, China                                      | Cohort                    | 851         | 297         | Patients with nosocomial SA bacteraemia                                                   | NR               | (81)     |
| Wehrhahn 2010        | 2 years                | Australia                                          | Prospective cohort        | 57          | 114         | Invasive community-onset SA infection                                                     | All ages         | (80)     |
| Wolkewitz 2011       | 2005–2006              | United Kingdom (Scotland)                          | Cohort                    | 34          | 26          | New hospital admission of health-care-associated SA bacteraemia                           | NR               | (79)     |
| Wyllie 2006          | 1997–2004 <sup>h</sup> | United Kingdom (England)                           | Cohort                    | 227         | 214         | Inpatients with SA bacteraemia                                                            | Adults ≥18 years | (78)     |
| Yoon 2005            | 1986–2004              | Republic of Korea                                  | Cohort                    | 10          | 22          | Patients with SA endocarditis                                                             | All ages         | (77)     |
| Zahar 2005           | 1997–2004              | France                                             | Cohort                    | 69          | 65          | Ventilator-associated pneumonia                                                           | Adults           | (76)     |

BSI, bloodstream infection; CT, computed tomography; E, European Union group; ICU, intensive care unit; L, Latin American group; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S. aureus*; N, nosocomial; PVL, Panton-Valentine leukocidin; SA, *S. aureus*; SAR, Special Administrative Region; SSTI, skin and soft tissue infection; USA, United States of America.

a. For some studies, the original study design may have been a case-control study assessing, for example, risk factors for infection. However, the authors also report for the case-control groups subsequent outcome data and, in this instance, for such outcomes the design would be considered a cohort.

b. Community-associated MRSA only.

c. Multi-drug resistant MRSA only; same study by Kuint comparing different cases to same controls.

d. Excluding May 2000 and September 2 – October 15 2000.

e. All MRSA cases were late onset only.

f. 33 episodes in 31 patients; 7 prosthetic joint infection episodes in 7 patients were polymicrobial.

g. 12 episodes in 12 patients; 2 prosthetic joint infection episodes in 2 patients were polymicrobial.

h. 1997–2004 at one hospital; 1999–2004 at another.



**Table A3.8 GRADE table for third-generation cephalosporin-resistant *Escherichia coli***  
**Question: Are clinical outcomes different in patients who are treated for third-generation cephalosporin (CEPH)-resistant *E. coli* when compared those treated for third-generation CEPH-sensitive *E. coli*?**

| Quality assessment                                                                                       |                                    |                           |                          |                         |                           |                                                                | No. of patients  |                | Effect                  |                                              | Quality      | Importance |
|----------------------------------------------------------------------------------------------------------|------------------------------------|---------------------------|--------------------------|-------------------------|---------------------------|----------------------------------------------------------------|------------------|----------------|-------------------------|----------------------------------------------|--------------|------------|
| No. of studies                                                                                           | Design                             | Risk of bias              | Inconsistency            | Indirectness            | Imprecision               | Other considerations                                           | CEPH-resistant   | CEPH-sensitive | Relative (95% CI)       | Absolute                                     |              |            |
| All-cause mortality (follow-up 3 to 60 days*; assessed with: death events)                               |                                    |                           |                          |                         |                           |                                                                |                  |                |                         |                                              |              |            |
| 16                                                                                                       | Observational studies <sup>b</sup> | Serious <sup>c</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision    | Strong association <sup>d</sup>                                | 188/1007 (18.7%) | 10.9%          | RR 2.18 (1.58 to 3.02)  | 129 more per 1000 (from 63 more to 220 more) | ⊕⊕⊕ LOW      | CRITICAL   |
| Bacterium-attributable mortality (follow-up 30 to 60 days; assessed with: death events)                  |                                    |                           |                          |                         |                           |                                                                |                  |                |                         |                                              |              |            |
| 4                                                                                                        | Observational studies <sup>e</sup> | Serious <sup>c</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision    | Reporting bias <sup>f</sup><br>Strong association <sup>g</sup> | 53/225 (23.6%)   | 12.6%          | RR 2.02 (1.41 to 2.90)  | 129 more per 1000 (from 52 more to 239 more) | ⊕⊕⊕ VERY LOW | CRITICAL   |
| 30 day mortality (follow-up 7 to 30 days*; assessed with: death events)                                  |                                    |                           |                          |                         |                           |                                                                |                  |                |                         |                                              |              |            |
| 11                                                                                                       | Observational studies              | Serious <sup>c</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision    | Strong association <sup>g</sup>                                | 153/711 (21.5%)  | 10.4%          | RR 2.19 (1.78 to 2.68)  | 124 more per 1000 (from 81 more to 175 more) | ⊕⊕⊕ LOW      | CRITICAL   |
| ICU admissions related to infection (follow-up mean 30 days; assessed with: number of patients admitted) |                                    |                           |                          |                         |                           |                                                                |                  |                |                         |                                              |              |            |
| 1                                                                                                        | Observational studies              | Very serious <sup>c</sup> | No serious inconsistency | No serious indirectness | Very serious <sup>h</sup> | Reporting bias <sup>i</sup>                                    | 2/17 (11.8%)     | 4.2%           | RR 2.78 (0.58 to 13.20) | 75 more per 1000 (from 18 fewer to 512 more) | ⊕⊕⊕ VERY LOW | IMPORTANT  |
| Total LOS (follow-up median 60 days*; measured with: days; better indicated by lower values)             |                                    |                           |                          |                         |                           |                                                                |                  |                |                         |                                              |              |            |
| 4                                                                                                        | Observational studies <sup>b</sup> | Serious <sup>c</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision    | Reporting bias <sup>f</sup>                                    | 226              | 612            | –                       | MD 1.8 days higher (1.3 lower to 5.0 higher) | ⊕⊕⊕ VERY LOW |            |
| Postinfection LOS (follow-up 3 to 30 days*; measured with: days; better indicated by lower values)       |                                    |                           |                          |                         |                           |                                                                |                  |                |                         |                                              |              |            |
| 4                                                                                                        | Observational studies <sup>b</sup> | Serious <sup>c</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision    | Reporting bias <sup>f</sup>                                    | 199              | 1705           | –                       | MD 2.3 day higher (0.3 lower to 4.9 higher)  | ⊕⊕⊕ VERY LOW |            |

CEPH, cephalosporin; CI, confidence interval; ICU, intensive care unit; LOS, length of stay; MD, mean difference; RR, relative risk.

a. Five studies did not report follow-up information; ambiguity in reporting follow-up information.

b. Majority of the studies are true cohort; for GRADE table all considered cohort.

c. Confounding is not properly adjusted.

d. Relative risk >2.

e. Lack of clarity in reporting duration of follow-up.

f. Only four studies identified.

g. Relative risk >2.

h. Single study with wide confidence interval.

i. Only three studies identified.

**Table A3.9** GRADE table for fluoroquinolone-resistant *Escherichia coli*

Question: Are clinical outcomes different in patients who are treated for fluoroquinolone (FQ)-resistant *E. coli* infection when compared to those treated for FQ-sensitive *E. coli* infection?

| Quality assessment                                                                                                               |                       |                           |                          |                         |                        |                                                                     | No. of patients  |              | Effect                   |                                               | Quality <sup>f</sup> | Importance    |
|----------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|--------------------------|-------------------------|------------------------|---------------------------------------------------------------------|------------------|--------------|--------------------------|-----------------------------------------------|----------------------|---------------|
| No. of studies                                                                                                                   | Design                | Risk of bias              | Inconsistency            | Indirectness            | Imprecision            | Other considerations                                                | FQ-resistant     | FQ-sensitive | Relative (95% CI)        | Absolute                                      |                      |               |
| All-cause mortality (follow-up 21 days to 6 years; assessed with: death events)                                                  |                       |                           |                          |                         |                        |                                                                     |                  |              |                          |                                               |                      |               |
| 8                                                                                                                                | Observational studies | Serious <sup>b</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | Strong association <sup>c</sup>                                     | 96/470 (20.4%)   | 7.9%         | RR 2.11 (1.64 to 2.71)   | 88 more per 1000 (from 51 more to 135 more)   | ⊕⊕⊕ LOW              | CRITICAL      |
| Bacterium-attributable mortality (follow-up mean not available; assessed with: death events)                                     |                       |                           |                          |                         |                        |                                                                     |                  |              |                          |                                               |                      |               |
| 1                                                                                                                                | Observational studies | Very serious <sup>b</sup> | No serious inconsistency | No serious indirectness | Very serious           | Reporting bias <sup>d</sup>                                         | 0/30 (0%)        | 00%          | –                        | –                                             | ⊕⊕⊕⊕ VERY LOW        |               |
| 30 days mortality (follow-up 1 to 3 months <sup>e</sup> ; assessed with: death events)                                           |                       |                           |                          |                         |                        |                                                                     |                  |              |                          |                                               |                      |               |
| 5                                                                                                                                | Observational studies | Serious <sup>b</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | Strong association <sup>g</sup>                                     | 203/1576 (12.9%) | 7.8%         | RR 2.16 (1.09 to 4.27)   | 90 more per 1000 (from 7 more to 255 more)    | ⊕⊕⊕ LOW              | CRITICAL      |
| LOS in hospital (follow-up 21 days to 3 months; measured with: days; better indicated by lower values)                           |                       |                           |                          |                         |                        |                                                                     |                  |              |                          |                                               |                      |               |
| 3                                                                                                                                | Observational studies | Serious <sup>b</sup>      | Serious <sup>h</sup>     | No serious indirectness | Serious <sup>i</sup>   | Reporting bias <sup>j</sup>                                         | 183              | 411          | –                        | MD 3.7 days higher (3.5 lower to 10.9 higher) | ⊕⊕⊕⊕ VERY LOW        | NOT IMPORTANT |
| ICU admission (follow-up mean 60 days; assessed with: patients admitted)                                                         |                       |                           |                          |                         |                        |                                                                     |                  |              |                          |                                               |                      |               |
| 1                                                                                                                                | Observational studies | Very serious <sup>b</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>k</sup><br>Strong association <sup>g</sup>      | 12/93 (12.9%)    | 5.40%        | RR 2.4 (1.08 to 5.35)    | 76 more per 1000 (from 4 more to 235 more)    | ⊕⊕⊕⊕ VERY LOW        |               |
| Progression to septic shock (follow-up mean 21 days <sup>l</sup> ; assessed with: number of patients progressed to septic shock) |                       |                           |                          |                         |                        |                                                                     |                  |              |                          |                                               |                      |               |
| 2                                                                                                                                | Observational studies | Very serious <sup>b</sup> | Serious                  | No serious indirectness | No serious imprecision | Reporting bias <sup>k</sup><br>Very strong association <sup>g</sup> | 5/132 (3.8%)     | 0.25%        | RR 10.00 (1.19 to 84.36) | 22 more per 1000 (from 0 more to 208 more)    | ⊕⊕⊕⊕ VERY LOW        |               |

CI, confidence interval; ICU, intensive care unit; FLQ, fluoroquinolone; LOS, length of stay; MD, mean difference; RR, relative risk.

a. In four studies follow-up information not available and ambiguity in reporting.

b. Confounding in majority of the studies a concern and/or small sample size.

c. Relative risk >2.

d. Just two studies identified.

e. Not available in one study.

f. High – randomized trials or double-upgraded observational studies; Moderate – downgraded randomized trials or upgraded observational studies; low – double-downgraded randomized trials or observational studies; Very low – triple-downgraded randomized trials; or downgraded observational studies; or case series/case reports.

g. Relative risk >2 or >5.

h. Disparity in effect size: of three studies; one shows no effect and in one effect size is not estimable.

i. Effect size varies across the studies by a wide margin.

j. Only three studies identified.

k. Single study identified.

l. In one study follow-up not reported.

l. Two studies identified.

**Table A3.10 GRADE table for third-generation cephalosporin-resistant *Klebsiella pneumoniae***  
**Question: Are clinical outcomes different in patients who are treated for third-generation cephalosporin (CEPH)-resistant *K. pneumoniae* when compared to those treated for third-generation CEPH-sensitive *K. pneumoniae* infection?**

| Quality assessment                                                                                                                         |                       |                           |                          |                         |                        |                             | No. of patients |                  | Effect                 |                                                             | Quality          | Importance |
|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|--------------------------|-------------------------|------------------------|-----------------------------|-----------------|------------------|------------------------|-------------------------------------------------------------|------------------|------------|
| No. of studies                                                                                                                             | Design                | Risk of bias              | Inconsistency            | Indirectness            | Imprecision            | Other considerations        | CEPH-resistant  | CEPH-sensitive   | Relative (95% CI)      | Absolute                                                    |                  |            |
| All-cause mortality (follow-up 21 to 316 days <sup>a</sup> ; assessed with: death events)                                                  |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 14                                                                                                                                         | Observational studies | Serious <sup>b</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | None                        | 183/574 (31.9%) | 211/1041 (20.3%) | RR 1.35 (1.14 to 1.61) | 71 more per 1000 (from 28 more to 124 more)                 | ⊕○○○<br>VERY LOW | CRITICAL   |
| Bacterium-attributable mortality (follow-up mean 30 days <sup>c</sup> ; assessed with: death events)                                       |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 4                                                                                                                                          | Observational studies | Serious <sup>b</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>d</sup> | 36/180 (20.0%)  | 17/169 (10.1%)   | RR 1.93 (1.13 to 3.31) | 94 more per 1000 (from 13 more to 232 more)                 | ⊕○○○<br>VERY LOW | CRITICAL   |
| 30 days mortality (follow-up 30 days; assessed with: death events)                                                                         |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 7                                                                                                                                          | Observational studies | Serious <sup>b</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | None                        | 96/318 (30.2%)  | 193/919 (21%)    | RR 1.45 (1.07 to 1.95) | 95 more per 1000 (from 15 more to 200 more)                 | ⊕○○○<br>VERY LOW | CRITICAL   |
| Total LOS in hospital (follow-up 21 to 316 days <sup>e</sup> ; measured with: number of days; better indicated by lower values)            |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 9                                                                                                                                          | Observational studies | Serious <sup>b</sup>      | No serious inconsistency | No serious indirectness | Serious <sup>f</sup>   | None                        | 369             | 950              | –                      | MD 15.8 days higher (2.6 lower to 34.2 higher)              | ⊕○○○<br>VERY LOW | IMPORTANT  |
| Postinfection LOS in hospital (follow-up 25 to 30 days <sup>g</sup> ; measured with: number of days; better indicated by lower values)     |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 4                                                                                                                                          | Observational studies | Very serious <sup>b</sup> | Serious <sup>h</sup>     | No serious indirectness | No serious imprecision | Reporting bias <sup>i</sup> | 128             | 266              | –                      | MD 13.1 days higher (0.7 lower to 26.9 higher) <sup>j</sup> | ⊕○○○<br>VERY LOW | IMPORTANT  |
| Infection-related ICU admission (follow-up mean 30 days <sup>g</sup> ; assessed with: number of patients admitted to ICU due to infection) |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 3                                                                                                                                          | Observational studies | Very serious <sup>b</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>d</sup> | 155/206 (75.2%) | 121/227 (53.3%)  | RR 1.39 (1.08 to 1.80) | 208 more per 1000 (from 43 more to 426 more)                | ⊕○○○<br>VERY LOW |            |
| Progression to septic shock (follow-up mean 30 days; assessed with: number of patients went into septic shock)                             |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                                             |                  |            |
| 3                                                                                                                                          | Observational studies | Very serious <sup>b</sup> | Serious <sup>h</sup>     | No serious indirectness | Serious <sup>f</sup>   | Reporting bias <sup>d</sup> | 33/161 (20.5%)  | 32/154 (20.8%)   | RR 0.99 (0.64, 1.53)   | 208 fewer per 1000 (from 208 fewer to 208 fewer)            |                  |            |

CEPH, cephalosporin; CI, confidence interval; ICU, intensive care unit; LOS, length of stay; MD, mean difference; RR, relative risk.

a. In eight studies the follow-up is not reported or unclear.

b. Cohort studies; issues related to confounding are not addressed adequately; follow-up is not reported or unclear.

c. In three studies follow-up not reported.

d. <5 studies; and all studies are small.

e. In five studies follow-up is unclear or not reported.

f. Wide confidence intervals.

g. Two studies not reported or unclear.

h. Effect size varies from no effect to large effect.

i. Only four studies identified.

j. Results too inconsistent to pool into a single estimate; although all the results indicated an increase for CEPH-resistant.

**Table A3.11 GRADE table for carbapenem-resistant *Klebsiella pneumoniae***  
**Question: Are clinical outcomes different in patients who are treated for carbapenem (CARB)-resistant *K. pneumoniae* when compared to those treated for CARB-sensitive *K. pneumoniae* infection?**

| Quality assessment                                                                                                                      |                       |                           |                          |                         |                        |                                                             | No. of patients |                 | Effect                 |                                                | Quality       | Importance |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|--------------------------|-------------------------|------------------------|-------------------------------------------------------------|-----------------|-----------------|------------------------|------------------------------------------------|---------------|------------|
| No. of studies                                                                                                                          | Design                | Risk of bias              | Inconsistency            | Indirectness            | Imprecision            | Other considerations                                        | Carba-resistant | Cepha-sensitive | RR (95% CI)            | Absolute                                       |               |            |
| All-cause mortality (follow-up 14 days to 1 year <sup>d</sup> ; assessed with: death events)                                            |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 11                                                                                                                                      | Observational studies | Serious <sup>a</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | None                                                        | 198/517 (38.3%) | 208/895 (23.2%) | RR 1.71 (1.35 to 2.18) | 165 more per 1000 (from 81 more to 274 more)   | ⊕○○○ VERY LOW | CRITICAL   |
| Bacterium-attributable mortality (follow-up not reported; assessed with: death events)                                                  |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 1                                                                                                                                       | Observational studies | Very serious <sup>a</sup> | No serious inconsistency | No serious indirectness | Serious <sup>b</sup>   | Reporting bias <sup>c</sup>                                 | 10/37 (27%)     | 3/22 (13.6%)    | RR 1.98 (0.61 to 6.43) | 134 more per 1000 (from 53 fewer to 740 more)  | ⊕○○○ VERY LOW | CRITICAL   |
| 30 days mortality (follow-up 28 to 30 days, not reported in one study; assessed with: death events)                                     |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 3                                                                                                                                       | Observational studies | Serious <sup>a</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>e</sup>                                 | 76/169 (45%)    | 97/326 (29.8%)  | RR 1.51 (1.19 to 1.91) | 152 more per 1000 (from 57 more to 271 more)   | ⊕○○○ VERY LOW | CRITICAL   |
| ICU mortality (follow-up not available; assessed with: death events)                                                                    |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 1                                                                                                                                       | Observational studies | Very serious <sup>a</sup> | no serious inconsistency | No serious indirectness | Serious <sup>b</sup>   | Reporting bias <sup>c</sup>                                 | 21/37 (56.8%)   | 9/22 (40.9%)    | RR 1.39 (0.78 to 2.47) | 160 more per 1000 (from 90 fewer to 601 more)  | ⊕○○○ VERY LOW |            |
| Total LOS in hospital (follow-up 28 days not available in two studies; measured with: number of days; better indicated by lower values) |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 3                                                                                                                                       | Observational studies | Serious <sup>a</sup>      | Serious <sup>f</sup>     | No serious indirectness | Serious <sup>g</sup>   | Reporting bias <sup>e</sup>                                 | 179             | 215             | –                      | MD 1.0 day higher (11.9 lower to 13.8 higher)  | ⊕○○○ VERY LOW | IMPORTANT  |
| Postinfection LOS (follow-up mean 30 days; measured with: number of days; better indicated by lower values)                             |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 1                                                                                                                                       | Observational studies | Very serious <sup>a</sup> | No serious inconsistency | No serious indirectness | Serious <sup>g</sup>   | Reporting bias <sup>c</sup>                                 | 103             | 214             | –                      | MD 5.0 days higher (21.7 lower to 31.7 higher) | ⊕○○○ VERY LOW | IMPORTANT  |
| Discharge to long-term care facility (follow-up not available; assessed with: number of patients discharged)                            |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 1                                                                                                                                       | Observational studies | Serious <sup>a</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>h</sup> strong association <sup>i</sup> | 15/19 (78.9%)   | 13/38 (34.2%)   | RR 2.31 (1.40 to 3.80) | 448 more per 1000 (from 137 more to 958 more)  | ⊕○○○ VERY LOW |            |
| Transfer to other health care facility (follow-up not available; assessed with: number of patients transferred)                         |                       |                           |                          |                         |                        |                                                             |                 |                 |                        |                                                |               |            |
| 1                                                                                                                                       | Observational studies | Very serious <sup>a</sup> | No serious inconsistency | No serious indirectness | Serious <sup>g</sup>   | Reporting bias <sup>c</sup>                                 | 2/19 (10.5%)    | 5/38 (13.2%)    | RR 0.80 (0.17 to 3.75) | 26 fewer per 1000 (from 109 fewer to 362 more) | ⊕○○○ VERY LOW |            |

CARB, carbapenem; CEPH, cephalosporin; CI, confidence interval; ICU, intensive care unit; LOS, length of stay; MD, mean difference; RR, relative risk.

- a. Cohort study; confounding is not addressed.  
b. Single study with wide confidence interval.  
c. Single study.  
d. Follow-up not reported in eight studies.  
e. Three studies less than 5.  
f. Ib = 59%; wide variation in effect size across studies.  
g. Wide confidence interval.  
h. No explanation was provided.  
i. RR > 2.

**Table A3.12 GRADE table for MRSA**

**Question: Are clinical outcomes different in patients who are treated for MRSA infection when compared to those treated for MSSA infection?**

| Quality assessment                                                               |                       |                      |                          |                         |                        |                      | No. of patients   |                  | Effect                 |                                              | Quality       | Importance |
|----------------------------------------------------------------------------------|-----------------------|----------------------|--------------------------|-------------------------|------------------------|----------------------|-------------------|------------------|------------------------|----------------------------------------------|---------------|------------|
| No. of studies                                                                   | Design                | Risk of bias         | Inconsistency            | Indirectness            | Imprecision            | Other considerations | MRSA              | MSSA             | Relative (95% CI)      | Absolute                                     |               |            |
| All-cause mortality (assessed with: death events)                                |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 107                                                                              | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 2448/37537 (6.5%) | 6.4%             | RR 1.61 (1.43 to 1.82) | 39 more per 1000 (from 28 more to 52 more)   | ⊕○○○ VERY LOW | CRITICAL   |
| Bacterium-attributable mortality (assessed with: death events)                   |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 46                                                                               | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 958/3646 (26.3%)  | 893/5271 (16.9%) | RR 1.64 (1.43 to 1.87) | 108 more per 1000 (from 73 more to 147 more) | ⊕○○○ VERY LOW | CRITICAL   |
| 30 days mortality (assessed with: death events)                                  |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 16                                                                               | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 1271/4549 (27.9%) | 939/6346 (14.8%) | RR 1.59 (1.33 to 1.91) | 87 more per 1000 (from 49 more to 135 more)  | ⊕○○○ VERY LOW | CRITICAL   |
| ICU mortality (assessed with: death events)                                      |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 5                                                                                | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 220/751 (29.3%)   | 171/838 (20.4%)  | RR 1.46 (1.23 to 1.74) | 94 more per 1000 (from 47 more to 151 more)  | ⊕○○○ VERY LOW | CRITICAL   |
| Total LOS in hospital (measured with: days; better indicated by lower values)    |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 50                                                                               | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 33 705            | 33 675           | –                      | MD 4.65 higher (2.96 to 6.33 higher)         | ⊕○○○ VERY LOW | CRITICAL   |
| Postinfection LOS (measured with: days; better indicated by lower values)        |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 27                                                                               | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 2539              | 2785             | –                      | MD 3.12 higher (1.79 to 4.44 higher)         | ⊕○○○ VERY LOW | CRITICAL   |
| ICU LOS (measured with: days; better indicated by lower values)                  |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 21                                                                               | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 1211              | 1699             | –                      | MD 4.00 higher (2.12 to 5.87 higher)         | ⊕○○○ VERY LOW | IMPORTANT  |
| Readmission (assessed with: number of patients readmitted)                       |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 6                                                                                | Observational studies | Serious <sup>a</sup> | Serious <sup>b</sup>     | No serious indirectness | No serious imprecision | None                 | 189/733 (25.8%)   | 241/1185 (20.3%) | RR 0.91 (0.67 to 1.23) | 18 fewer per 1000 (from 67 fewer to 47 more) | ⊕○○○ VERY LOW | IMPORTANT  |
| ICU admission (assessed with: number of patients admitted to ICU)                |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 17                                                                               | Observational studies | Serious <sup>a</sup> | Serious <sup>b</sup>     | No serious indirectness | No serious imprecision | None                 | 364/1397 (26.1%)  | 461/1936 (23.8%) | RR 1.07 (0.92 to 1.25) | 17 more per 1000 (from 19 fewer to 60 more)  | ⊕○○○ VERY LOW | IMPORTANT  |
| Progression to septic shock (assessed with: patients progressed to septic shock) |                       |                      |                          |                         |                        |                      |                   |                  |                        |                                              |               |            |
| 21                                                                               | Observational studies | Serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | None                 | 275/1756 (15.7%)  | 354/3559 (9.9%)  | RR 1.52 (1.24 to 1.88) | 52 more per 1000 (from 24 more to 88 more)   | ⊕○○○ VERY LOW | IMPORTANT  |

| Quality assessment                                                                                                   |                       |                           |                          |                         |                        |                             | No. of patients |                  | Effect                 |                                              | Quality          | Importance |
|----------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|--------------------------|-------------------------|------------------------|-----------------------------|-----------------|------------------|------------------------|----------------------------------------------|------------------|------------|
| No. of studies                                                                                                       | Design                | Risk of bias              | Inconsistency            | Indirectness            | Imprecision            | Other considerations        | MRSA            | MSSA             | Relative (95% CI)      | Absolute                                     |                  |            |
| Mechanical ventilation (assessed with: number of patients put on mechanical ventilator)                              |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                              |                  |            |
| 14                                                                                                                   | Observational studies | Serious <sup>a</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | None                        | 340/713 (47.7%) | 407/1329 (30.6%) | RR 1.07 (0.92 to 1.24) | 21 more per 1000 (from 24 fewer to 73 more)  | ⊕○○○<br>VERY LOW | IMPORTANT  |
| Discharge to long-term care facility (assessed with: number of patients discharger to long-term care)                |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                              |                  |            |
| 1                                                                                                                    | Observational studies | Serious <sup>a</sup>      | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>c</sup> | 47/150 (31.3%)  | 26/128 (20.3%)   | RR 1.54 (1.02 to 2.34) | 110 more per 1000 (from 4 more to 272 more)  | ⊕○○○<br>VERY LOW | CRITICAL   |
| Discharge to other health care facility (assessed with: number of patients discharged to other health-care facility) |                       |                           |                          |                         |                        |                             |                 |                  |                        |                                              |                  |            |
| 1                                                                                                                    | Observational studies | Very serious <sup>a</sup> | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias <sup>c</sup> | 10/29 (34.5%)   | 15/121 (12.4%)   | RR 2.78 (1.4 to 5.55)  | 221 more per 1000 (from 50 more to 564 more) | ⊕○○○<br>VERY LOW | IMPORTANT  |

CI, confidence interval; ICU, intensive care unit; LOS, length of stay; MD, mean difference; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S. aureus*; RR, relative risk.

a. Confounding was not taken into account in all studies and/or sample size was very small in some studies.

b. Wide variation in effect size across studies.

c. Single study.

**Table A3.13** Complete overview of findings on costs addressing the question:  
*Does the published scientific literature support that there is an excess costs outcome in infections caused by the following bacteria if they are resistant to the following antibacterials, respectively?*

| First author              | Total no.                    |                              | Data, unit of cost                                                                                                                              | Resources costed                                                                                                                                                               | Resistant cost             | Susceptible cost          | Reported cost differential                                                                                                                                                                                                                                                                                              | PICO outcomes                                                           |
|---------------------------|------------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
|                           | Sensitive                    | Resistant                    |                                                                                                                                                 |                                                                                                                                                                                |                            |                           |                                                                                                                                                                                                                                                                                                                         |                                                                         |
| <i>E. coli</i>            | ESBL                         | Non-ESBL                     |                                                                                                                                                 |                                                                                                                                                                                |                            |                           |                                                                                                                                                                                                                                                                                                                         |                                                                         |
| Apisarnthanarak 2008 (37) | 46                           | 138                          | Median, USD (\$)                                                                                                                                | <b>Hospital costs accrued after infection</b> (direct and indirect costs required to provide health-care services and medications)                                             | \$528 (43–3173)            | \$194 (53–1861)           |                                                                                                                                                                                                                                                                                                                         | Crude mortality                                                         |
| Tumbarello 2010 (19)      | 37                           | 97                           | Mean, euros (€)                                                                                                                                 | <b>Total hospital costs:</b> direct health care costs (total expenditures incurred by the hospital to provide services or goods for each patient with a bloodstream infection) | €13 709 ±16 312            | €8683 ±6683               | Cost difference related to ESBL production vs non-ESBL production (by BSI case): €5026 vs €4322 2006 US\$ 6314 vs 5429                                                                                                                                                                                                  | Postinfection LOS; 21 days mortality                                    |
|                           |                              |                              |                                                                                                                                                 | <b>Medical care</b>                                                                                                                                                            | €1964 ±417                 | €1134 ±83                 |                                                                                                                                                                                                                                                                                                                         |                                                                         |
|                           |                              |                              |                                                                                                                                                 | <b>Nursing care</b>                                                                                                                                                            | €3894 ±1078                | €2001 ±163                |                                                                                                                                                                                                                                                                                                                         |                                                                         |
|                           |                              |                              |                                                                                                                                                 | <b>Pharmacy services</b> (all drugs)                                                                                                                                           | €933 ±1706                 | €848 ±1434                |                                                                                                                                                                                                                                                                                                                         |                                                                         |
|                           |                              |                              |                                                                                                                                                 | <b>Diagnostic testing</b> (includes laboratory and imaging studies)                                                                                                            | €2373 ±2734                | €1760 ±1974               |                                                                                                                                                                                                                                                                                                                         |                                                                         |
|                           |                              |                              |                                                                                                                                                 | <b>Support services</b> (includes food service, laundry, maintenance, security, etc.)                                                                                          | €1674 ±1983                | €1016 ±723                |                                                                                                                                                                                                                                                                                                                         |                                                                         |
|                           |                              |                              |                                                                                                                                                 | <b>Others</b> (includes utilities, admission/ discharge, depreciation, and overhead costs)                                                                                     | €2869 ±2676                | €1921 ±2152               |                                                                                                                                                                                                                                                                                                                         |                                                                         |
|                           |                              |                              |                                                                                                                                                 | <b>Antimicrobial drug treatment</b> (also accounted for in pharmacy services above)                                                                                            | €763 ±437                  | €474 ±270                 |                                                                                                                                                                                                                                                                                                                         |                                                                         |
| <i>S. aureus</i>          | MRSA                         | MSSA                         |                                                                                                                                                 |                                                                                                                                                                                |                            |                           |                                                                                                                                                                                                                                                                                                                         |                                                                         |
| Anderson 2009 (217)       | 150 (144 had financial data) | 128 (127 had financial data) | Median IQR, USD (\$) 2003 (All hospital charges were adjusted to reference year 2003 by inflating charges from prior years at a 3% annual rate) | <b>Hospital charges</b> (Including readmissions); no further details reported                                                                                                  | \$79 029 (38 113, 127 846) | \$55 667 (22 201, 86 757) | Attributable difference least squares mean (IQR) Unadjusted: \$36 379 (13 509, 59 250) Adjusted ( <i>surgical duration &gt;75th NNIS percentile, ASA score &gt;3, procedure at tertiary care hospital, Charlson score &gt;3, surgery on same day as admission, and coronary artery bypass graft surgery</i> ): \$24 113 | Readmission within 90 days; post-procedure LOS; LOS attributable to SSI |

| First author         | Total no. |           | Data, unit of cost            | Resources costed                                                                                                                                                                                                                                                                  | Resistant cost                                                              | Susceptible cost                                                           | Reported cost differential                                                   | PICO outcomes                                   |
|----------------------|-----------|-----------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------|
|                      | Sensitive | Resistant |                               |                                                                                                                                                                                                                                                                                   |                                                                             |                                                                            |                                                                              |                                                 |
| Ben-David 2009 (209) | 95        | 87        | USD (\$) 2003                 | <b>Total hospital actual cost</b><br>(As opposed to charges)<br>BSI occurred while in ICU<br>BSI occurred while in general unit                                                                                                                                                   | ICU:<br>113 852<br>(48 961–55 001)<br>Non-ICU:<br>53 409<br>(32 945–84 053) | ICU:<br>42 137<br>(32 388–74 781)<br>Non-ICU:<br>35 131<br>(18 340–50 896) | $P < .001$<br>$P .005$                                                       | LOS after infection; ICU<br>LOS after infection |
|                      |           |           |                               | <b>Subtotal hospital cost after BSI</b><br>BSI occurred while in ICU<br>BSI occurred while in general unit                                                                                                                                                                        | ICU:<br>51 492<br>(24 535–104 499)<br>Non-ICU:<br>23 690<br>(13 545–43 375) | ICU:<br>17 603<br>(10 228–42 117)<br>Non-ICU:<br>18 152<br>(11 091–33 202) | $P < .001$<br>$P .3$                                                         |                                                 |
|                      |           |           |                               | <b>Daily hospital cost after BSI</b><br>BSI occurred while in ICU<br>BSI occurred while in general unit<br>(Subtotal and daily hospital costs also available for pre-infection hospitalization)                                                                                   | ICU:<br>2894<br>(1902–3553)<br>Non-ICU:<br>1756<br>(1329–2113)              | ICU:<br>2042<br>(1487–2472)<br>Non-ICU:<br>1565<br>(1227–1882)             | $P .005$<br>$P .1$                                                           |                                                 |
| Capitano 2003 (206)  | 41        | 49        | Median (range), USD (\$) 2003 | <b>All infection-related costs incurred by long-term care facility</b><br>Total pharmaceutical: infection-related medication acquisition, determination of drug levels, pharmacist dispensing, pharmacist monitoring, adverse effect, and nursing medication administration costs | \$332<br>(17–1552)                                                          | \$269<br>(49–1216)                                                         | Authors state total cost associated with MRSA was 1.95 X greater<br>$P .425$ | Relapse                                         |
|                      |           |           |                               | <b>Infection management:</b><br>Infection-related microbiological cultures, laboratories, X-rays, ambulance transfers and isolation costs                                                                                                                                         | \$562<br>(31–2457)                                                          | \$93<br>(14–912)                                                           | $P < .001$                                                                   |                                                 |
|                      |           |           |                               | <b>Physician care:</b> Infection-related consulting physician fee and primary physician care                                                                                                                                                                                      | \$248<br>(0–2078)                                                           | \$184<br>(0–1736)                                                          | $P .227$                                                                     |                                                 |
|                      |           |           |                               | <b>Nursing care:</b> Nursing and certified nursing assistant care                                                                                                                                                                                                                 | \$1347<br>(399–4847)                                                        | \$610<br>(102–2550)                                                        | $P .001$                                                                     |                                                 |
|                      |           |           |                               | <b>Total infection cost:</b> The sum of all previously defined associated costs                                                                                                                                                                                                   | \$2607<br>(849–8895)                                                        | \$1332<br>(268–7265)                                                       | $P < .001$                                                                   |                                                 |



| First author               | Total no. |           | Data, unit of cost        | Resources costed                                                                                                                                                                                                                                        | Resistant cost                             | Susceptible cost                         | Reported cost differential                                                                                                                                                                                                                                                                                                                                                                                             | PICO outcomes                                                                          |
|----------------------------|-----------|-----------|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
|                            | Sensitive | Resistant |                           |                                                                                                                                                                                                                                                         |                                            |                                          |                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                        |
| <b>Cosgrove 2005 (194)</b> | 96        | 252       | Median IQR, USD (\$)      | <b>Total hospital charges:</b><br>(From the hospital's billing system) starting on day of bacteraemia through to discharge<br><br><b>Hospital costs:</b> Estimated by adjusting charges using the overall Medicare cost-to-charge ratio for institution | \$26 424<br>(\$14 006–\$50 484)            | \$19 212<br>(\$9999–\$36 548)            | Mean attributable MRSA \$6916<br><br>\$3836 = median charge or cost for MSSA bacteraemia X multiplicative effect for increased charges or costs due to MRSA bacteraemia<br><br>MRSA associated with 1.19-fold increase in median hospital cost ( <i>P</i> .03) (adjusting for duration of surgery, hospital, length of hospitalization before infection, length of ICU stay before infection, renal disease, diabetes) | LOS postinfection<br><br>Post-surgery, postinfection and postinfection ICU             |
| <b>Engemann 2003 (187)</b> | 121       | 165       | Median IQR, mean USD (\$) | <b>Hospital costs</b> (Hospital charges as direct cost data were not available); 90 day postoperative period                                                                                                                                            | \$92 363<br>(40 198, 136 479)<br>\$118 415 | \$52 791<br>(29 074, 91 805)<br>\$73 165 |                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                        |
| <b>Erdem 2010 (185)</b>    | 15        | 47        | Median IQR, USD (\$)      | <b>Hospital costs:</b> Patient billing charges; no other info available                                                                                                                                                                                 | \$44 000<br>(37 000, 106 000)              | \$22 000<br>(14 000, 40 000)             | <i>P</i> .0045                                                                                                                                                                                                                                                                                                                                                                                                         | LOS (after infection); ICU admission (after infection); septic shock (after admission) |

| First author      | Total no. |           | Data, unit of cost            | Resources costed                                                                                                                           | Resistant cost               | Susceptible cost           | Reported cost differential | PICO outcomes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------|-----------|-----------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|----------------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | Sensitive | Resistant |                               |                                                                                                                                            |                              |                            |                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Filice 2010 (183) | 335       | 390       | Median (range), USD (\$) 2007 | <b>Total cost:</b>                                                                                                                         | \$34 657 (\$11 517–\$98 287) | \$15 923 (\$5270–\$45 684) | $P < .001$                 | Postinfection LOS; postinfection ICU LOS; septic shock Use and cost data were collected from the VA Decision Support System – all direct and indirect costs of care, including services provided by contracted non-VA providers. The costs and services were quantified for each day during the 6 months after onset of SA illness. As well, they conducted interviews to estimate costs incurred by patients or third-party payers for care received from sources outside the Minneapolis VA Medical Center |
|                   |           |           |                               | <b>INPATIENT TREATMENT:</b> (Includes room and board, patient acuity costs, nutrition, and some identified in-hospital medical care costs) |                              |                            |                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Overall inpatient costs</b>                                                                                                             | \$26 274 (\$4531–\$86,974)   | \$6748 (\$0–\$35 089)      | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Basic inpatient costs</b>                                                                                                               | \$16 416 (\$2661–\$54 180)   | \$3820 (\$0–\$21 913)      | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Inpatient antimicrobial agents</b>                                                                                                      | \$142 (\$6–\$508)            | \$21 (\$0–\$337)           | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Other drugs</b>                                                                                                                         | \$1530 (\$242–\$5502)        | \$406 (\$0–\$2394)         | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Laboratory tests</b>                                                                                                                    | \$1002 (\$179–\$2749)        | \$362 (\$0–\$1249)         | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Imaging</b>                                                                                                                             | \$1048 (\$0–\$5453)          | \$227 (\$0–\$1597)         | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Surgical procedures</b>                                                                                                                 | \$0 (\$0–\$3432)             | \$0 (\$0–\$378)            | $P .02$                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>PMR</b>                                                                                                                                 | \$0 (\$0–\$731)              | \$0 (\$0–\$98)             | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Mental, social and spiritual</b>                                                                                                        | \$459 (\$33–\$1280)          | \$80 (\$0–\$750)           | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Haemodialysis</b>                                                                                                                       | \$0 (\$0–\$0)                | \$0 (\$0–\$0)              | $P .42$                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Other</b> (Includes home care costs while the patient was hospitalized, inpatient fee-basis costs, and other noncategorized costs)      | \$1307 (\$9–\$5818)          | \$100 (\$0–\$1980)         | $P < .001$                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>OUTPATIENT TREATMENT:</b> Overall outpatient costs                                                                                      | \$4322 (\$1395–\$9438)       | \$4495 (\$2076–\$8979)     | $P .30$                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Outpatient basic clinic costs</b>                                                                                                       | \$1169 (\$345–\$2494)        | \$1344 (\$626–\$2571)      | $P .05$                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                   |           |           |                               | <b>Outpatient antimicrobial agents</b>                                                                                                     | \$2 (\$0–\$28)               | \$7 (\$0–\$32)             | $P .01$                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

| First author         | Total no. |           | Data, unit of cost   | Resources costed                                                                                                                                                                                                      | Resistant cost                | Susceptible cost              | Reported cost differential | PICO outcomes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------|-----------|-----------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-------------------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | Sensitive | Resistant |                      |                                                                                                                                                                                                                       |                               |                               |                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Filice<br>2010 (183) |           |           |                      | Other drugs                                                                                                                                                                                                           | \$766 (\$41–\$1979)           | \$793 (\$173–\$1678)          | <i>P</i> .72               | Postinfection LOS; postinfection ICU LOS; septic shock<br>Use and cost data were collected from the VA Decision Support System – all direct and indirect costs of care, including services provided by contracted non-VA providers. The costs and services were quantified for each day during the 6 months after onset of SA illness. As well, they conducted interviews to estimate costs incurred by patients or third-party payers for care received from sources outside the Minneapolis VA Medical Center |
|                      |           |           |                      | Laboratory tests                                                                                                                                                                                                      | \$171 (\$0–\$450)             | \$232 (\$95–\$484)            | <i>P</i> .005              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | Imaging                                                                                                                                                                                                               | \$95 (\$0–\$446)              | \$146 (\$0–\$506)             | <i>P</i> .04               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | Surgical procedures                                                                                                                                                                                                   | \$0 (\$0–\$374)               | \$44 (\$0–\$451)              | <i>P</i> .13               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | PMR                                                                                                                                                                                                                   | \$0 (\$0–\$0)                 | \$0 (\$0–\$0)                 | <i>P</i> .75               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | Mental, social and spiritual                                                                                                                                                                                          | \$0 (\$0–\$108)               | \$0 (\$0–\$83)                | <i>P</i> .09               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | Haemodialysis                                                                                                                                                                                                         | \$0 (\$0–\$0)                 | \$0 (\$0–\$0)                 | <i>P</i> .63               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | Other (Includes costs for outpatient observation [room and board, acuity, nutrition, and some costs incurred while patient was under observation status], outpatient fee-basis costs, and other noncategorized costs) | \$661 (\$51–\$2106)           | \$652 (\$158–\$1976)          | <i>P</i> .37               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Kopp<br>2004 (151)   | 36        | 36        | Median IQR, USD (\$) | Hospital cost:                                                                                                                                                                                                        | \$16 575 (\$7275–\$89 157)    | \$12 862 (\$5292–\$36 471)    | <i>P</i> 0.11              | Mechanical ventilation; total LOS; total ICU LOS<br>Paper does not specify if costs are included for post infection period only                                                                                                                                                                                                                                                                                                                                                                                 |
|                      |           |           |                      | Hospital charge:                                                                                                                                                                                                      | \$50 059 (\$22 200–\$215 752) | \$40 102 (\$14 775–\$112 278) | <i>P</i> 0.162             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

| First author           | Total no. |           | Data, unit of cost                                                           | Resources costed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Resistant cost                                                      | Susceptible cost                                                    | Reported cost differential | PICO outcomes                      |
|------------------------|-----------|-----------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------|------------------------------------|
|                        | Sensitive | Resistant |                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                     |                                                                     |                            |                                    |
| Lepelletier 2004 (147) | 24        | 64        | Mean, euros (€)                                                              | <b>Cost of hospitalization</b> = (LOS) x (Average price/ day in ICU)                                                                                                                                                                                                                                                                                                                                                                                                                                    | €37 278 (6344–121 329)                                              | €27 755 (7930–121 329)                                              |                            | Total LOS; mortality               |
|                        |           |           |                                                                              | <b>Cost of antibiotic therapy</b> = (total dosage of each molecule received by the patient) x (corresponding unit price)                                                                                                                                                                                                                                                                                                                                                                                | €184 (8–1202)                                                       | €72 (2–350)                                                         |                            |                                    |
|                        |           |           |                                                                              | <b>Cost of medical care per patient:</b> used a model relating to the Omega score (measures medical costs in euros by giving a score based on how long the patient was in the ICU, whether they had a surgical procedure or invasive radiology); this model does not include fixed costs or staff costs                                                                                                                                                                                                 | €12 345 (1255–26 260)                                               | €10 632 (2207–24 351)                                               |                            |                                    |
| Lodise 2005 (143)      | 170       | 183       | Continuous variable log transformed and expressed as mean (95% CI), USD (\$) | <b>Overall cost of hospitalization after onset of SA bacteraemia,</b> includes fixed indirect costs, variable direct costs, fixed direct costs<br>Fixed indirect: from departments that do not provide direct patient care services (ie. housekeeping, medical records, billing, etc);<br>Variable direct: cost of patient care services (ie. nursing staff, medications, etc.);<br>Fixed direct: not captured in patient care services (ie. administration, clerical support, building overhead, etc.) | \$22 735<br>Excludes patients that died secondary to SA bacteraemia | \$11 205<br>Excludes patients that died secondary to SA bacteraemia |                            | Post LOS; mortality (attributable) |
|                        |           |           |                                                                              | <b>Adjusted cost – SA bacteraemia,</b> used ANCOVA to analyse mean group difference while adjusting for confounding variables (APACHE II score at onset of SA bacteraemia, ICU at onset of SA bacteraemia, and hospital-acquired SA bacteraemia, hospital days prior to onset of SA bacteraemia, and intravenous drug use source of SA bacteraemia)                                                                                                                                                     | \$21 577 (17 061–27 290)                                            | \$11 668 (9550–14 223)                                              |                            |                                    |

| First author         | Total no. |           | Data, unit of cost    | Resources costed                                                                                                                                                                                                                                                           | Resistant cost          | Susceptible cost        | Reported cost differential | PICO outcomes                           |
|----------------------|-----------|-----------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|----------------------------|-----------------------------------------|
|                      | Sensitive | Resistant |                       |                                                                                                                                                                                                                                                                            |                         |                         |                            |                                         |
| McHugh<br>2004 (138) | 20        | 40        | USD (\$)              | <b>Total charge during hospitalization</b>                                                                                                                                                                                                                                 | \$45 920                | \$9699                  |                            | Total LOS; mortality                    |
|                      |           |           |                       | <b>Cost per patient-day of hospitalization</b>                                                                                                                                                                                                                             | \$5878                  | \$2073                  |                            |                                         |
|                      |           |           |                       | <b>Cost per patient-day for patients with low CMI* (<math>\leq 2</math>)</b> [less severe illness] *CMI (case mix index) cost: weighted measure of severity of illness (average of 2 for the study patients and is greater than the general population [1 is the average]) | \$2715                  | \$2462                  |                            |                                         |
|                      |           |           |                       | <b>Cost per patient-day for patients with high CMI (<math>&gt; 2</math>)</b> [poorer health status]                                                                                                                                                                        | \$9744                  | \$4442                  | \$5302                     |                                         |
| Ott<br>2010 (126)    | 41        | 41        | Median IQR, euros (€) | <b>Overall costs per patient</b>                                                                                                                                                                                                                                           | €60 684 (23 127–93 468) | €38 731 (15 365–47 814) | –                          | Post LOS; total LOS; ICU LOS; mortality |
|                      |           |           |                       | <b>Cost of nursing staff</b>                                                                                                                                                                                                                                               | €14 424                 | €9389                   |                            |                                         |
|                      |           |           |                       | <b>Cost of assistant medical technicians</b>                                                                                                                                                                                                                               | €5813                   | €3551                   |                            |                                         |
|                      |           |           |                       | <b>Cost for pharmacy</b>                                                                                                                                                                                                                                                   | €5533                   | €1165                   |                            |                                         |
|                      |           |           |                       | <b>Cost for medical products</b>                                                                                                                                                                                                                                           | €5408                   | €3533                   |                            |                                         |
|                      |           |           |                       | <b>Median costs attributable to methicillin resistance in SA pneumonia per patient</b> (different in costs of the matched pairs)                                                                                                                                           | –                       | –                       | €17 281 (–929–53 541)      |                                         |
|                      |           |           |                       | <b>Reimbursement per patient</b>                                                                                                                                                                                                                                           | €47 480 (21 082–81 302) | €32 369 (11 853–48 048) | –                          |                                         |
|                      |           |           |                       | <b>Loss per patient</b> (financial loss per patient for the hospital) = costs–reimbursement                                                                                                                                                                                | €11 701 (2203–21 981)   | €2662 (–2103–617)       | –                          |                                         |
|                      |           |           |                       | <b>Loss attributable to methicillin resistance in SA pneumonia per patient</b> (difference of median loss of the matched pairs)                                                                                                                                            | –                       | –                       | €4418 (–1905–22 035)       |                                         |

| First author       | Total no. |           | Data, unit of cost | Resources costed                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Resistant cost        | Susceptible cost    | Reported cost differential | PICO outcomes                                                                                                                                       |
|--------------------|-----------|-----------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
|                    | Sensitive | Resistant |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                     |                            |                                                                                                                                                     |
| Park 2011          | 53        | 53        | 2008 USD (\$)      | <b>Total hospital costs</b><br>(includes cost of hospital stay, laboratory tests, care and treatments)*<br><u>*Cost of hospital stay</u> = cost from administration, clerical support, housekeeping and medical records); <u>Cost of care</u> = cost of physician care, nursing care, and consultations; <u>Treatment costs</u> = total drug costs, costs of materials (catheters and implanted devices) and costs of procedures (operations, dialysis, respiratory care, rehabilitation) | \$9369.6<br>±12 911.5 | \$8355.8<br>±8959.3 |                            | Post LOS; total LOS; mortality Note 3                                                                                                               |
|                    |           |           |                    | <b>Basic inpatient costs</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                              | \$1957.1<br>±2518.8   | \$1649.8<br>±1749.5 |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Laboratory tests</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | \$1463.3<br>±2057.6   | \$1694.1<br>±2192.5 |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Imaging</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | \$446.9<br>±641.7     | \$622.7<br>±817.4   |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Drugs</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | \$3485.9<br>±6277.2   | \$2692.0<br>±3722.2 |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Haemodialysis</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$729.6<br>±1235.1    | \$476.2<br>±970.7   |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Surgical procedure</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | \$68.1<br>±218.1      | \$203.1<br>±393.4   |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Consultation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | \$147.9<br>±171.2     | \$155.4<br>±169.8   |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Others</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | \$1031.8<br>±1617.9   | \$874.8<br>±1219.8  |                            |                                                                                                                                                     |
| Parvizi 2010 (124) | 231       | 160       | 2009 USD (\$)      | <b>In-hospital costs</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | \$107 264<br>±110 953 | \$68 053<br>±50 354 |                            | Total LOS<br>Data also available for cost per procedure (resection, re-revision, re-implantation; dealing with prosthetic joint infection patients) |
|                    |           |           |                    | <b>Cost per hospital stay</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                             | \$30 580<br>±31 752   | \$22 779<br>±18 385 |                            |                                                                                                                                                     |
|                    |           |           |                    | <b>Cost per hospital day</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                              | \$3173<br>±2850       | \$3473<br>±2269     |                            |                                                                                                                                                     |

| First author            | Total no. |           | Data, unit of cost | Resources costed                                                                                                                                                                                                                                                 | Resistant cost                                                               | Susceptible cost                                                           | Reported cost differential | PICO outcomes                                                                                                                                    |
|-------------------------|-----------|-----------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | Sensitive | Resistant |                    |                                                                                                                                                                                                                                                                  |                                                                              |                                                                            |                            |                                                                                                                                                  |
| Reed 2005 (113)         | 54        | 89        | 2001 USD (\$)      | <b>Cost of index hospitalization</b> (includes costs incurred before positive blood culture) = inpatients costs and physician fees for initial inpatient stay                                                                                                    | Mean = \$28 297<br>±23 619<br>Median (min-max) = \$21 322<br>(12 315–34 933) | Mean = \$16 066<br>±16 337<br>Median (min-max) = \$12 908<br>(7920–18 174) |                            | Total LOS; post LOS; ICU LOS; in-hospital and 12 weeks mortality; 12 weeks relapse; discharge to home or other long-term care facility<br>Note 5 |
|                         |           |           |                    | <b>Total cost during 12 weeks</b> (only 14.8% of MRSA and 12.4% of MSSA patients were rehospitalized within 12 weeks) = costs of index hospitalization + costs for outpatient care and rehospitalizations related to SA bacteraemia or its sequelae              | Mean = \$32 655<br>±25 313<br>Median (min-max) = \$25 968<br>(13 072–45 008) | Mean = \$18,803<br>±17,929<br>Median (min-max) = \$15 017<br>(8960–20 053) |                            |                                                                                                                                                  |
| Rubio-Terres 2010 (108) | 121       | 245       | Mean, euros (€)    | <b>Total cost per episode of bacteraemia</b> (base value of the use of resources and of the unit cost) – includes cost of empirical antibiotic, targeted antibiotic, complementary tests, hospitalization/ICU, and consultations and intravenous administration) | €11 044.59                                                                   | €9839.25                                                                   | €1205.34                   | Total LOS; ICU LOS; crude and attributable mortality; ICU admission; readmission                                                                 |
|                         |           |           |                    | <b>Cost of hospitalization/ICU</b> (included in total cost above)                                                                                                                                                                                                | €8703.86                                                                     | €6917.51                                                                   | €1786.35                   |                                                                                                                                                  |
|                         |           |           |                    | <b>Empirical antibiotic</b>                                                                                                                                                                                                                                      | €51.05                                                                       | €36.69                                                                     | €14.36                     |                                                                                                                                                  |
|                         |           |           |                    | <b>Targeted antibiotic</b>                                                                                                                                                                                                                                       | €285.12                                                                      | €128.55                                                                    | €156.57                    |                                                                                                                                                  |
|                         |           |           |                    | <b>Complementary tests</b>                                                                                                                                                                                                                                       | €1820.50                                                                     | €2572.44                                                                   | €–751.94                   |                                                                                                                                                  |
|                         |           |           |                    | <b>Consultations and intravenous administration</b>                                                                                                                                                                                                              | €184.06                                                                      | €184.06                                                                    | €0                         |                                                                                                                                                  |

| First author            | Total no. |           | Data, unit of cost   | Resources costed                                                                                                                                                                                                                                                                                                                                                                                   | Resistant cost                                    | Susceptible cost                                  | Reported cost differential                                                                                                                                                                                                  | PICO outcomes                                                                                                         |
|-------------------------|-----------|-----------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
|                         | Sensitive | Resistant |                      |                                                                                                                                                                                                                                                                                                                                                                                                    |                                                   |                                                   |                                                                                                                                                                                                                             |                                                                                                                       |
| <b>Shorr 2006 (103)</b> | 95        | 59        | Median IQR, USD (\$) | <b>Total cost</b> = (operating cost/charge ratio + capital cost/charge ratio) x total charge<br>Operating cost = (hospital specific cost/charge ratio) x hospital total charges<br>Computed total costs by taking component charges for the hospital stay (pharmacy, laboratory, bed day, etc.) and multiplied them by the Medicare cost-to-charge ratios. These were summed to derive total costs | \$40 734<br>(18 347–71 064)                       | \$36 523<br>(15 539–72 080)                       | \$7731<br>(–8393– +23 856)<br>Attributable excess cost from multivariate analysis of MRSA vs MSSA after controlling for surgical and trauma status, time of onset of ventilator-associated pneumonia and admission severity | Total LOS; crude mortality                                                                                            |
| <b>Shorr 2010 (102)</b> | 87        | 55        | USD (\$)             | <b>Total hospital charges for all services provided between hospital admission and discharge</b>                                                                                                                                                                                                                                                                                                   | Mean = \$98 170<br>±94 707<br>Median = \$70 028   | Mean = \$104 121<br>±91 314<br>Median = \$71 186  |                                                                                                                                                                                                                             | Total LOS; mortality; ICU admission; receipt of mechanical ventilation                                                |
| <b>Taneja 2010 (93)</b> | 55        | 73        | USD (\$)             | <b>Total hospital charges for all services provided between hospital admission and discharge</b>                                                                                                                                                                                                                                                                                                   | Mean = \$117 489<br>±132 164<br>Median = \$71 868 | Mean = \$135 784<br>±170 046<br>Median = \$84 593 |                                                                                                                                                                                                                             | Total LOS; in-hospital and 30 days mortality (for those discharged); receipt of mechanical ventilation; ICU admission |

ASA, American Society of Anesthesiologists; BSI, bloodstream infection; CI, confidence interval; CMI, case mix index; ESBL, extended spectrum beta-lactamases; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; MRSA, methicillin-resistant *S. aureus*; MSSA, methicillin-susceptible *S. aureus*; NNIS, National Nosocomial Infections Surveillance; PICO, population; intervention; comparison; outcome; SA, *S. aureus*; SSI, surgical site infections; VA, veterans affairs.



## A3.3 References

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# Appendix 1

## Questionnaires used for data collection

### Ap1.1 Questionnaire and data template for national antimicrobial resistance (AMR) surveillance

|                                                                                         | Surveillance data                                                                                                                                                                     |                     |                                                                |                                                                                            | Type of source for data (tick for each resistance)<br>(to understand if there is one common national report on AMR or several sources for information for the different bacteria) |                                                                               |                                                                         |                                                 |                                                                                                        | Contact information                                                                                          |
|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
|                                                                                         | Year                                                                                                                                                                                  | Resistance rate (%) | Figure based on following number of tested isolates (if given) | Comprehensiveness (all isolates), or targeted, (e.g. only invasive isolates) surveillance? | AMR report to government?                                                                                                                                                         | AMR report/ compilation at national body/institute, reference lab or similar. | Report of mandatory surveillance, Communicable diseases act or similar. | Other national/regional report on AMR situation | No, there is no national compilation on AMR of this resistance, please tick and continue under 2 below |                                                                                                              |
| 1/ Resistance rates                                                                     |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        | Please provide name of body/institute and name + e-mail to focal point/contact person(s) for the information |
| <i>E. coli</i> (3 <sup>rd</sup> gen. cephalosporins)                                    |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>E. coli</i> (fluoroquinolones)                                                       |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>K. pneumoniae</i> (3 <sup>rd</sup> gen. cephalosporins)                              |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>K. pneumoniae</i> (carbapenems)                                                      |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>Salmonella</i> spp (fluoroquinolones)                                                |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>Shigella</i> spp (fluoroquinolones)                                                  |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>N. gonorrhoeae</i> (decreased susceptibility to 3 <sup>rd</sup> gen. cephalosporins) |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>S. pneumoniae</i> (penicillin resistance, oxacillin)                                 |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| <i>S. aureus</i> (methicillin, MRSA)                                                    |                                                                                                                                                                                       |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |
| 2/ Additional info on surveillance of antibacterial resistance in your country          | Provide name/address/web-page/email of body/institute and focal point/contact person(s) in other surveillance network(s) or other centers engaged in ABR surveillance in your country |                     |                                                                |                                                                                            |                                                                                                                                                                                   |                                                                               |                                                                         |                                                 |                                                                                                        |                                                                                                              |



## Ap1.2 Questionnaire and data template for antimicrobial resistance (AMR) surveillance networks

|    |                                                                                                                                                                                                                                                                                                               |                                                       |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| 1/ | <b>General information on network/ institution</b>                                                                                                                                                                                                                                                            |                                                       |
|    | Name of network/ institution                                                                                                                                                                                                                                                                                  |                                                       |
|    | Name and e-mail to contact person                                                                                                                                                                                                                                                                             |                                                       |
|    | Address to web-page (if any)                                                                                                                                                                                                                                                                                  |                                                       |
|    | Geographical coverage (i.e. in which country, or if several countries, which participating countries)?                                                                                                                                                                                                        |                                                       |
|    | Number of sites participating? If in several countries, please specify per country                                                                                                                                                                                                                            |                                                       |
|    | Is the resistance rate figure based on inclusion of all clinical isolates (comprehensive, write C) or limited to only a subset of isolates, write S, and in case of «S» also which types of isolates (e.g. blood, ICU etc). In any case (C or S), please state whether screening samples are included or not. |                                                       |
|    | Are resistance results based on quantitative data (MIC, zone diameters) or on qualitative (i.e. SIR)?                                                                                                                                                                                                         |                                                       |
|    | Which breakpoint standards are used (CLSI, EUCAST, OTHER)                                                                                                                                                                                                                                                     |                                                       |
|    | Does a majority of the laboratories, or the institution, generating data have an internal QA-strategy ?                                                                                                                                                                                                       |                                                       |
|    | Does a majority of the laboratories in the network, or the institution, participate in external QA?                                                                                                                                                                                                           |                                                       |
|    | Does a majority of laboratories, or the institution, enter data in a digital system in their own lab (Y/N)?                                                                                                                                                                                                   | Is WHONET used for this purpose (y/n)                 |
|    | Does the participants in the network, or the institution, transfer data to coordinator digitally (y/n)?                                                                                                                                                                                                       | Does network coordinator manage data in WHONET (y/n)? |

| 2/ | Resistance rates                                                                                                                                       |                                                                 |                                           |                     |              |                            |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------|---------------------|--------------|----------------------------|
|    | Bacteriae                                                                                                                                              | Antibiotic class                                                | Please enter compound you use for testing | Year data collected | % resistance | Number of tested isolates: |
|    | <i>E. coli</i>                                                                                                                                         | 3 <sup>rd</sup> generation cephalosporins                       |                                           |                     |              |                            |
|    | <i>E. coli</i>                                                                                                                                         | quinolones, preferably fluoroquinolones                         |                                           |                     |              |                            |
|    | <i>K. pneumoniae</i>                                                                                                                                   | 3 <sup>rd</sup> generation cephalosporins                       |                                           |                     |              |                            |
|    | <i>K. pneumoniae</i>                                                                                                                                   | carbapenems                                                     |                                           |                     |              |                            |
|    | <i>P. aeruginosa</i>                                                                                                                                   | carbapenems                                                     |                                           |                     |              |                            |
|    | <i>Salmonella spp</i> (non-typhi)                                                                                                                      | quinolones, preferably fluoroquinolones                         |                                           |                     |              |                            |
|    | <i>Shigella spp</i>                                                                                                                                    | quinolones, preferably fluoroquinolones                         |                                           |                     |              |                            |
|    | <i>S. aureus</i> , (MRSA)                                                                                                                              | oxacillin/cefoxitin                                             |                                           |                     |              |                            |
|    | <i>S. pneumoniae</i>                                                                                                                                   | non-susceptible to penicillin                                   |                                           |                     |              |                            |
|    | <i>S. pneumoniae</i>                                                                                                                                   | co-trimoxazole                                                  |                                           |                     |              |                            |
|    | <i>N. gonorrhoeae</i>                                                                                                                                  | decreased susceptibility to 3 <sup>rd</sup> gen. cephalosporins |                                           |                     |              |                            |
| 3/ | Please provide in the cells below additional information on other surveillance network(s) or other centers engaged in ABR surveillance in your country |                                                                 |                                           |                     |              |                            |
|    | Name of focal point/ contact person                                                                                                                    |                                                                 |                                           |                     |              |                            |
|    | Web-page of network or institution                                                                                                                     |                                                                 |                                           |                     |              |                            |
|    | Additional information or comments                                                                                                                     |                                                                 |                                           |                     |              |                            |



# Appendix 2

## WHO tools to facilitate surveillance of antibacterial resistance

The following are some of the key WHO tools, documents and recommendations addressing surveillance of antimicrobial resistance (AMR), in particular, antibacterial resistance (ABR). Other documents specifically address surveillance of resistance in the disease-specific programmes on tuberculosis (TB), malaria, HIV and influenza, and are cited in the respective sections of this report.

### Ap2.1 WHONET

WHONET is freely available database software for the management and analysis of microbiology laboratory data with a special focus on the analysis of AST results. WHONET supports ABR surveillance, including data-sharing, but it is not a surveillance network.

Development and dissemination of the software is guided by two objectives:

- enhancing the use of data for local needs; and
- promoting local, national, regional and global collaborations through the exchange of data and sharing of experiences.

Continuing development of the software depends critically on the expressed needs and feedback of users around the world in a number of fields. Current features of WHONET include:

- data entry of clinical and microbiological information from routine diagnostic testing or from research studies;
- data capture from existing laboratory information systems and susceptibility test instruments into WHONET using the BacLink data import module of WHONET;
- modular configuration allowing for the customization of the software for local clinical, research and epidemiological needs;
- analysis of laboratory findings, including isolate line listings, AST statistics, studies of multidrug-resistance patterns, microbiological and epidemiological alert notifications, and hospital and community outbreak detection;

- integrated susceptibility test interpretation guidelines for most standardized testing methodologies;
- simple data file structure and output formats compatible with major database, spread sheet, statistical and word processing software; and
- software use in interactive mode for ad hoc analyses, or automated mode for regularly scheduled analyses and notifications.

The WHONET software can be downloaded from the WHO website.<sup>a</sup> WHONET runs on all modern versions of Microsoft Windows (Windows 98 and later); it can also be run on Linux and Macintosh computers using Windows emulators. Currently, most facilities use WHONET 5.6, a desktop version of the software that is suitable for use on individual computers or in local area networks (LANs). A new web-based version of WHONET (WHONET 2013) is currently being pilot tested. It permits remote secure data entry into centralized databases hosted by surveillance network coordinators. Access to data analysis features is configurable by database administrators, and can support both open data access without passwords (e.g. of aggregate statistics and charts) and restricted password-protected access (e.g. selective access to appropriate data subsets only by network participants).

The software is multilingual and currently available in Bulgarian, Chinese, English, Estonian, French, German, Greek, Indonesian, Italian, Japanese, Mongolian, Norwegian, Portuguese, Russian, Spanish, Thai and Turkish.

<sup>a</sup> [http://www.who.int/medicines/areas/rational\\_use/AMR\\_WHONET\\_SOFTWARE/en/](http://www.who.int/medicines/areas/rational_use/AMR_WHONET_SOFTWARE/en/)

## Ap2.2 Guiding WHO documents for surveillance of AMR

### General and comprehensive recommendations



[http://www.who.int/drugresistance/WHO\\_Global\\_Strategy.htm/en/](http://www.who.int/drugresistance/WHO_Global_Strategy.htm/en/)

#### WHO Global Strategy for Containment of Antimicrobial Resistance (2001) (1)

The strategy provides a framework of interventions to slow the emergence and reduce the spread of antimicrobial-resistant microorganisms through:

- reducing the disease burden and the spread of infection;
- improving access to appropriate antimicrobials;
- improving use of antimicrobials;
- strengthening health systems and their surveillance capacities;
- enforcing regulations and legislation; and
- encouraging the development of appropriate new drugs and vaccines.



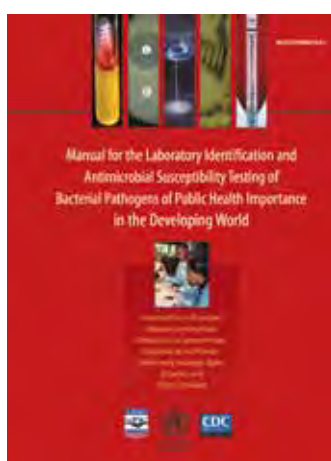
<http://www.who.int/world-health-day/2011/policybriefs/en/index.html>

#### World Health Day 2011: policy briefs (2011) (2)

In the six-point policy package, WHO called on all key stakeholders to act and take responsibility in six main areas to combat antimicrobial resistance:

- develop and implement a comprehensive, financed national plan
- strengthen surveillance and laboratory capacity
- ensure uninterrupted access to essential medicines of assured quality
- regulate and promote rational use of medicines
- enhance infection prevention and control
- foster innovation and research and development for new tools.

### Antimicrobial susceptibility testing



<http://www.who.int/csr/resources/publications/drugresist/en/IAMRmanual.pdf>

#### Manual for the laboratory identification and antimicrobial susceptibility testing of bacterial pathogens of public health importance in the developing world (2003) (3)

This manual describes the tests needed to confirm the identification and antimicrobial susceptibility profile of seven bacterial pathogens of public health importance causing outbreaks of pneumonia, meningitis, enteric disease and gonorrhoea. A set of appendices provides more detail on such topics as media and reagents, primary isolation, packaging and shipping of infectious material, and preservation and storage of isolates. The manual is intended for use in a reference laboratory or national central laboratory that is adequately resourced and staffed.

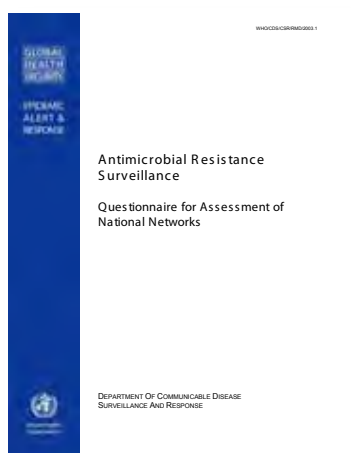
## Surveillance of antimicrobial resistance



[http://whqlibdoc.who.int/hq/2002/WHO\\_CDS\\_CSR\\_DRS\\_2001.5.pdf](http://whqlibdoc.who.int/hq/2002/WHO_CDS_CSR_DRS_2001.5.pdf)

### Surveillance standards for antimicrobial resistance (2002) (4)

The document is a brief manual covering the core microbiological and epidemiological principles relevant for surveillance of antimicrobial resistance. Special attention is given to confounding factors that may undermine the validity of results from such programmes. A separate section contains protocols for integrated surveillance of communicable diseases and resistance.



<http://www.who.int/drugresistance/whocdscsrrmd20031.pdf>

### Antimicrobial resistance surveillance: Questionnaire for assessment of national networks (2003) (5)

The questionnaire is one component of a strategy for quality assessment. Component I aims to provide a means for laboratory networks currently active in antimicrobial resistance surveillance to assess the status of the individual laboratories in the network with respect to:

- basic laboratory capacity and infrastructure (Part 1);
- the ability to isolate and identify bacterial isolates (Part 2); and
- the performance of antimicrobial susceptibility testing (Part 3).

Component II is a tool for evaluating the network coordinating centre and the overall functioning of the surveillance network.



<http://apps.who.int/medicinedocs/en/m/abstract/Js16168e/>

### Community-based surveillance of antimicrobial use and resistance in resource-constrained settings. Report on five pilot projects (2009) (6)

Integrated surveillance of antimicrobial resistance and use at all levels of health care is an essential component of any programme to contain antimicrobial resistance. There is currently no standard methodology for conducting community-based surveillance in resource-constrained settings. This document describes five pilot surveillance projects that were set up in India (three sites) and South Africa (two sites), with the aim of developing a model for undertaking integrated community-based surveillance in resource-constrained settings and generating baseline data.

## Regional documents



[http://www.who.int/csr/ihr/lyon/Policy\\_procedures\\_eqa\\_en.pdf](http://www.who.int/csr/ihr/lyon/Policy_procedures_eqa_en.pdf)

### Policy and procedures of the WHO/NICD Microbiology External Quality Assessment Programme in Africa (1.42M) (2007) (7)

The programme has served as a model for regional and national external quality assessment (EQA) within Africa and beyond. The purpose of the document is to:

- describe the WHO/National Institute for Communicable Diseases (NICD) microbiology EQA programme;
- describe current policies and procedures;
- provide samples of technical documents; and
- summarize previous surveys of laboratory capacity to detect certain infectious agents.



<http://apps.who.int/medicinedocs/documents/s20135en/s20135en.pdf>

### Guide for establishing laboratory-based surveillance for antimicrobial resistance (2013) (8)

The WHO Regional Office for Africa developed this guide to facilitate establishment of laboratory-based surveillance for priority bacterial diseases in the WHO African Region.



<http://www1.paho.org/common/Display.asp?Lang=E&RecID=10980>

### Recommendations of a group of experts: Standards for the use of automated identification systems for bacteria and susceptibility to antimicrobials. Brasilia, Brazil, 26–28 October 2004 (2005) (9)



## Ap2.3 ICD 10 codes for antimicrobial resistance

The *International statistical classification of diseases and related health problems* 10th Revision (ICD-10) Version for 2010 (10) provides in chapter XXII "Codes for special purposes" (U00-U89). One of these sections addresses "bacterial agents resistant to antibiotics". These were updated in 2009 and implemented in 2013 (11) as follows:

- U82 Resistance to beta-lactam antibiotics  
Use additional code (B95-B98), if desired, to identify agents resistant to beta-lactam antibiotic treatment.
- U82.0 Resistance to penicillin  
Resistance to amoxicillin, ampicillin
- U82.1 Resistance to methicillin  
Resistance to cloxacillin  
flucloxacillin, oxacillin
- U82.2 Extended spectrum beta-lactamase (ESBL) resistance
- U82.8 Resistance to other beta-lactam antibiotics
- U82.9 Resistance to beta-lactam antibiotics, unspecified
- U83 Resistance to other antibiotics: Use additional code (B95-B98), if desired,

to identify agents resistant to other antibiotic treatment.

- U83.0 Resistance to vancomycin U83.1.  
Resistance to other vancomycin-related antibiotics
- U83.2 Resistance to quinolones
- U83.7 Resistance to multiple antibiotics
- U83.8 Resistance to other single specified antibiotics
- U83.9 Resistance to unspecified antibiotics.  
Resistance to antibiotics NOS

Note: These categories should never be used in primary coding. They are provided for use as supplementary or additional codes when it is desired to identify the antibiotic to which a bacterial agent is resistant, in bacterial infection classified elsewhere.

It is possible to make some tailored amendments for national purposes. For example, South Africa assigned the codes U51 and U52 to *multidrug-resistant tuberculosis* (MDR-TB) and *extensively drug-resistant tuberculosis* (XDR-TB) respectively, and added these to the *tuberculosis* (A15-A19) broad group of causes of death (12).

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# Appendix 3

## Additional international antibacterial resistance surveillance networks

Surveillance networks have been developed for different reasons, including professional initiatives, time-limited projects, and commercial or security purposes. Some of these networks have (or have had) activities in several WHO regions. Identified networks or initiatives collecting ABR data for non-commercial purposes in more than one country are listed below.

### Ap3.1 Networks performing general surveillance of antibacterial resistance

AFHSC-GEIS<sup>a</sup> is the Global Emerging Infections Surveillance & Response System (GEIS) operated by the US Armed Forces Health Surveillance Center (AFHSC). It includes a programme for surveillance of antimicrobial resistant organisms from which some data on ABR have been published (1).

The Asian Network for Surveillance of Resistant Pathogens (ANSORP<sup>b</sup>) — is an independent, non-profit nongovernmental international collaborative research group on AMR and infectious diseases in the Asian-Pacific region. ANSORP is based in the Republic of Korea, which is a member of the Asia Pacific Foundation for Infectious Diseases (APFID). ANSORP includes collaborators from 123 hospitals in 14 countries, territories and areas.<sup>c</sup> The ANSORP network has studied various bacteria and the etiology of infectious diseases syndromes during different time periods. Current areas of interest, involving multinational collaboration, include community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA), community-acquired pneumonia, hospital-acquired pneumonia, multidrug-resistant Gram-negative pathogens, and drug-resistant *Streptococcus pneumoniae* and disease burden of pneumococcal infections.

The Antibiotic Resistance Surveillance and Control in the Mediterranean Region (ARMed) was a 4-year project financed by the European Commission's Directorate General for Research during 2003–2007. Centres from Cyprus, Egypt, Jordan, Malta (coordinator), Morocco, Tunisia and Turkey participated and presented data on ABR in the region (2). The activity ceased when funding terminated.

The BSAC Resistance Surveillance Project<sup>d</sup> monitors antibacterial drug resistance in England, Wales, Scotland, Northern Ireland and the Republic of

Ireland. Bacterial isolates are collected by a network of laboratories in these countries. Central laboratory services for the programme are provided by Public Health England.

The US CDC Global Disease Detection program<sup>e</sup> has recently conducted AMR surveillance activities in 10 countries, as part of capacity-building related to surveillance, response and control of emerging infectious diseases, including AMR. Most activities are country-specific. In Egypt, a recent research project included university and a few public hospitals for surveillance of hospital-acquired infections and ABR. Systematic surveillance for antimicrobial resistance has been conducted on population-based surveillance platforms in Kenya, Guatemala and Thailand.

The WHO Gonococcal Antimicrobial Surveillance Programme (GASP) was established in 1992 in the Western Pacific Region, and since then a global laboratory network has been developed to coordinate gonococcal antimicrobial resistance surveillance, monitor longitudinal trends in antimicrobial resistance and provide data to inform treatment guidelines. In each WHO region there is a GASP coordinating laboratory that works in partnership with the corresponding WHO regional office. The regional coordinating laboratory provides technical support to countries to strengthen laboratory capacity, and an external quality assessment programme including maintenance and distribution of the WHO panels of *N. gonorrhoeae* reference strains for quality assurance (3).

Médecins Sans Frontières (MSF) is a medical nongovernmental organization working in more than 60 countries to assist people whose survival is threatened by violence, neglect or catastrophe. MSF collects data on bacterial resistance among

<sup>a</sup> <http://www.afhsc.mil/geisAntiMicro> (accessed 16 October 2013)

<sup>b</sup> [http://www.ansorp.org/06\\_ansorp/ansorp\\_01.htm](http://www.ansorp.org/06_ansorp/ansorp_01.htm) (accessed 16 October 2013)

<sup>c</sup> India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Saudi Arabia, Singapore, Sri Lanka, Thailand, Viet Nam, in addition to China, Hong Kong SAR and Taiwan, China

<sup>d</sup> <http://www.bsacsurv.org> (accessed 16 October 2013)

<sup>e</sup> <http://www.cdc.gov/globalhealth/gdder/gdd> (accessed 16 October 2013)

some patient groups in some locations of activity, in area where most of this data are missing (e.g. rural, displaced population, war zone). To compile local data, MSF is developing and increasing its current network capacity focusing on orthopaedic hospitalized patients from the Middle East region, and malnourished children in sub-Saharan Africa. MSF findings in several countries around the world raise concerns about the high proportions of ABR in sampled patients in emergency settings.<sup>a</sup>

The Pasteur Institute has an international network of 32 institutes, which has a project "CHARLI" (*Children's Antibiotic Resistant infections in Low-Income countries: an international cohort study*) for which the main objective is to assess the incidence as well as the medical and economic consequences of severe childhood and neonatal infections caused by ABR bacteria.<sup>b</sup>

RusNet<sup>c</sup> is based in the Russian Federation and is coordinated by the Institute of Antimicrobial Chemotherapy (IAC) of the Smolensk State Medical Academy, Scientific Center on Monitoring Antimicrobial Resistance, and the Interregional Association for

Clinical Microbiology and Antimicrobial Chemotherapy (IACMAC). RusNet collects the national data for the Russian Federation; it also has collaboration with a few centres in four other countries.<sup>d</sup> Presently the network has 21–42 participating sites (depending on study). Collected samples are classified according to diagnosis and whether they originate from community or hospital-acquired infections.

The commercially driven surveillance networks or projects that have previously delivered data on ABR in support of drug development and marketing – for example, SENTRY, MYSTIC and SMART – were not approached during preparation of this report. According to another recent mapping, most of these networks are no longer active (4).

The list of internationally active surveillance networks is probably incomplete. Further mapping of national and regional networks, including additional specific pathogen-based networks, is required for better understanding of the full range of current activities worldwide, and identification of further opportunities for coordination and collaboration.

<sup>a</sup> <http://www.msf.org/search?keyword=resistance>

<sup>b</sup> <http://www.pasteur-international.org/ip/easysite/pasteur-international-en/scientific-activities/projects> (accessed 18 December 2013)

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ISBN 978 92 4 156474 8



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