ecdc
EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL

SURVEILLANCE REPORT

Antimicrobial resistance surveillance in Europe

2011

www.ecdc.europa.eu

Antimicrobial resistance surveillance in Europe

Annual report of the European Antimicrobial Resistance Surveillance Network (EARS-Net)

2011

The European Centre for Disease Prevention and Control (ECDC) wishes to thank all EARS-Net participating laboratories and hospitals in the Member States for providing data for this report.

Furthermore, all EARS-Net participants and National Epidemiological Contact Points are acknowledged for facilitating data transfer and providing valuable comments for this report. The ECDC's staff members Silvia Sarbu and Dana Ursut, and WHONET representative John Stelling are acknowledged for data management and providing technical support to the participating countries.

ECDC's staff members Liselotte Diaz Högberg and Ole Heuer are acknowledged for the preparation of the report, and Christine Walton at UK NEQAS is acknowledged for her contribution to Annex 1. In addition, the ECDC wishes to thank EARS-Net Coordination group members Christian Giske, Hajo Grundmann, Vincent Jarlier, Gunnar Kahlmeter, Jolanta Miciuleviciene, Jos Monen, Gian Maria Rossolini, Gunnar Skov Simonsen, Nienke van de Sande-Bruinsma and Helena Zemlickova for providing valuable comments and scientific advice during the production of the report.

Suggested citation for full report:
European Centre for Disease Prevention and Control. Antimicrobial resistance surveillance in Europe 2011. Annual Report of the European Antimicrobial Resistance Surveillance Network (EARS-Net). Stockholm: ECDC; 2012.

Cover picture © istockphoto

ISSN 1831-9491

ISBN 978-92-9193-398-3

doi 10.2900/6551

Contents

List of tables

List of figures

Abbreviations and acronyms

3GCREC	Third-generation cephalosporin-resistant *Escherichia coli*
3GCRKP	Third generation cephalosporin-resistant *Klebsiella pneumoniae*
AMR	Antimicrobial resistance
AmpC	Ampicillinase C
AST	Antimicrobial susceptibility testing
BSAC	British Society for Antimicrobial Chemotherapy
BSI	Bloodstream infection
CC	Clonal complex
CLSI	Clinical and Laboratory Standards Institute
CMY	Cephamycinase
CPE	Carbapenemase-producing *Enterobacteriaceae*
CRG	Commissie Richtlijnen Gevoeligheidsbepalingen (Dutch)
DIN	Deutsche Industrie Norm (German)
DNA	Deoxyribonucleic acid
EARSS	European Antimicrobial Resistance Surveillance System
EARS-Net	European Antimicrobial Resistance Surveillance Network
ECDC	European Centre for Disease Prevention and Control
EEA	European Economic Area
EU	European Union
EQA	External quality assessment
ESBL	Extended-spectrum beta-lactamase
ESGARS	ESCMID Study Group for Antimicrobial Resistance Surveillance
ICU	Intensive care unit
IMP	Imipenemase
KPC	*Klebsiella pneumoniae* carbapenemase
MIC	Minimum inhibitory concentration
MLS	Macrolide, lincosamide and streptogramin
MRSA	Meticillin-resistant *Staphylococcus aureus*
NDM	New Delhi metallo-beta-lactamase
NWGA	Norwegian Working Group on Antimicrobials
OXA	Oxacillinase gene
PBP	Penicillin-binding protein
PCV	Pneumococcal conjugate vaccine
RNA	Ribonucleic acid
SFM	Comité de l'Antibiogramme de la Société Française de Microbiologie (French)
SIR	Susceptible, intermediate, resistant
SHV	Sulfhydryl-variable extended-spectrum beta-lactamase gene
SRGA	Swedish Reference Group for Antibiotics
TESSy	The European Surveillance System (at ECDC)
TEM	Temoneira extended-spectrum beta-lactamase gene
UK NEQAS	United Kingdom National External Quality Assessment Scheme for Microbiology
VIM	Verona integron-encoded metallo-beta-lactamase

National institutions/organisations participating in EARS-Net

Austria
Federal Ministry of Health
Medical University Vienna
Elisabethinen Hospital, Linz
www.elisabethinen.or.at

Belgium
Scientific Institute of Public Health
www.iph.fgov.be
University of Antwerp

Bulgaria
Alexander University Hospital, Sofia
National Center of Infectious and Parasitic Diseases

Cyprus
Nicosia General Hospital

Czech Republic
National Institute of Public Health
www.szu.cz
National Reference Laboratory for Antibiotics

Denmark
Statens Serum Institut, Danish Study Group for Antimicrobial Resistance Surveillance (DANRES)
www.danmap.org

Estonia
Health Board
East-Tallinn Central Hospital
Tartu University Hospital

Finland
National Institute for Health and Welfare, Finnish Hospital Infection Program (SIRO)
www.thl.fi/siro
Finnish Study Group for Antimicrobial Resistance (FiRe)
www.finres.fi

France
Pitié-Salpêtrière Hospital
National Institute for Public Health Surveillance
www.invs.sante.fr
French National Observatory for the Epidemiology of Bacterial Resistance to Antimicrobials (ONERBA): Azay-Résistance, Île-de-France and Réussir networks
www.onerba.org
National Reference Centre for Pneumococci (CNRP)

Germany
Robert Koch Institute
www.rki.de

Greece
Hellenic Pasteur Institute
National School of Public Health
National and Kapodistrian University of Athens, Medical School
www.mednet.gr/whonet

Hungary
National Centre for Epidemiology
www.antsz.hu

Iceland
National University Hospital of Iceland
Centre for Health Security and Infectious Disease Control

Ireland
Health Protection Surveillance Centre (HPSC)
www.hpsc.ie

Italy
National Institute of Health
www.simi.iss.it/antibiotico_resistenza.htm

Latvia
Paul Stradins Clinical University Hospital
State Agency 'Infectology Centre of Latvia'

Lithuania
National Public Health Surveillance Laboratory
www.nvspl.lt
Institute of Hygiene
www.hi.lt

Luxembourg
National Health Laboratory
Microbiology Laboratory, Luxembourg's Hospital Centre

Malta
Mater Dei Hospital, B'Kara

Netherlands
National Institute for Public Health and the Environment
www.rivm.nl

Norway
University Hospital of North Norway
Norwegian Institute of Public Health
St. Olav University Hospital, Trondheim

Poland
National Medicines Institute
National Reference Centre for Antimicrobial Resistance and Surveillance

Portugal

National Institute of Health Dr. Ricardo Jorge
www.insarj.pt
Ministry of Health
Directorate-General of Health

Romania

National Institute of Research and Development for Microbiology and Immunology 'Cantacuzino'
Institute of Public Health

Slovakia

National Reference Centre for Antimicrobial Resistance
Public Health Authority of the Slovak Republic
Regional Public Health Authority Banska Bystrica

Slovenia

National Institute of Public Health
University of Ljubljana

Spain

Health Institute Carlos lll
www.isciii.es
National Centre of Microbiology

Sweden

Swedish Institute for Communicable Disease Control
www.smi.se

United Kingdom

Health Protection Agency
www.hpa.org.uk
Health Protection Scotland
Public Health Agency Northern Ireland

Summary

The results presented in this report are based on antimicrobial resistance data from invasive isolates reported to EARS-Net by 29 EU/EEA countries in 2012 (data referring to 2011), and on trend analyses of EARSS/EARS-Net data reported by the participating countries during the period 2008 to 2011.

The results show a general Europe-wide increase of antimicrobial resistance in the gram-negative pathogens under surveillance (*Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*), whereas the occurrence of resistance in the gram-positive pathogens (*Streptococcus pneumoniae*, *Staphylococcus aureus*, *Enterococcus faecium* and *Enterococcus faecalis*) appears to be stabilising or even decreasing in some countries. For most pathogen–antimicrobial combinations, large inter-country variations are evident.

In 2011, the most alarming evidence of increasing antimicrobial resistance in Europe came from data on combined resistance (resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides) in *E. coli* and in *K. pneumoniae*. For both of these pathogens, more than one third of the reporting countries had significantly increasing trends of combined resistance over the last four years.

The high and increasing percentage of combined resistance observed for *K. pneumoniae* means that for some patients with life-threatening infections, only a few therapeutic options remain available, e.g. carbapenems. However since 2010, carbapenem-resistance has increased in a number of countries, further aggravating the situation. For *P. aeruginosa*, combined resistance is also common, with 15% of the isolates resistant to at least three of the antimicrobial classes under surveillance. The seemingly unimpeded increase of antimicrobial resistance in the major gram-negative pathogens will unavoidably lead to loss of therapeutic treatment options.

In parallel, other trends of antimicrobial resistance reported to EARS-Net indicate that national efforts on infection control and containment of resistance are effective, as illustrated by the trends for meticillin-resistant *S. aureus* (MRSA), antimicrobial-resistant *S. pneumoniae* and antimicrobial-resistant enterococci, for which the situation appears generally stable or even improving in some countries. For MRSA, these observations are consistent with reports from the national surveillance programmes of some Member States and recent scientific studies on the results of infection control efforts. Large inter-country variations can be noted for *S. pneumoniae*, but non-susceptibility to commonly used antimicrobials has remained relatively stable in Europe during recent years, and this observation was confirmed by the 2011 data.

High-level aminoglycoside resistance in *E. faecalis* seems stable in Europe and several countries which previously reported relatively high levels of resistance now have decreasing trends. Likewise, the occurrence of vancomycin-resistance in *E. faecium* is stabilising or decreasing.

For several antimicrobial–pathogen combinations, e.g. fluoroquinolone-resistance in *E. coli*, *K. pneumoniae*, *P. aeruginosa* and for MRSA, a north-to-south gradient is evident in Europe. In general, lower resistance percentages are reported in the north and higher percentages in the south of Europe. These geographical differences may reflect differences in infection control practices and antimicrobial use in the reporting countries. Prudent use of antimicrobial agents and comprehensive infection control measures should be cornerstones of effective prevention and control efforts aimed at reducing the selection and transmission of antimicrobial-resistant bacteria

1 Introduction

Antimicrobial resistance (AMR) is a serious threat to public health in Europe, leading to mounting healthcare costs, treatment failure, and deaths. The issue calls for concerted efforts at Member State level but also close international cooperation in order to preserve future antimicrobial effectiveness and access to effective treatment for bacterial infections.

Surveillance of AMR is a fundamental part of an effective response to this threat, and surveillance results constitute an essential source of information on the magnitude and trends of resistance. Surveillance of AMR at EU level has been assured by European law: AMR is listed as a special health issue in Annex 1 of Commission Decision 2000/96/EC on the communicable diseases to be progressively covered by the Community network under Decision No 2119/98/EC of the European Parliament and of the Council[i]; surveillance of antimicrobial resistance within the EU/EEA is carried out in accordance with Regulation (EC) No 851/2004 of the European Parliament and of the Council of 21 April 2004 establishing a European Centre for Disease Prevention and Control (ECDC)[ii]. Over the years, the need for the Member States to collaborate on AMR surveillance has been reinforced by several council conclusions including the Council Conclusion on Antimicrobial Resistance of 10 June, 2008 and the recent Council Conclusion on the impact of antimicrobial resistance in the human health sector and in the veterinary sector – a 'one Health' perspective of 22 June 2012[iii].

About EARS-Net

The European Antimicrobial Resistance Surveillance Network (EARS-Net) is the continuation of the European Antimicrobial Resistance Surveillance System (EARSS), which was hosted by the Dutch National Institute for Public Health and the Environment (RIVM). Established in 1998, EARSS successfully created a multistate network for AMR surveillance and demonstrated how international AMR data could be provided to inform decisions and raise awareness among stakeholders and policy makers. By 1 January 2010, the management and administration of EARSS was transferred from RIVM to the European Centre for Disease Prevention and Control (ECDC), and the network was renamed EARS-Net. Data collected from EU Member States by the network since 1999 was transferred to The European Surveillance System (TESSy) database at ECDC.

EARS-Net is based on a network of representatives from the Member States collecting routine clinical antimicrobial susceptibility data from national AMR surveillance initiatives (for details, please refer to the list of national institutions and organisations participating in EARS-Net: page vii). Scientific guidance and support to the network is provided by the EARS-Net Coordination Group. This is composed of individual experts selected from among the nominated disease-specific contact points and experts from other organisations that are involved in surveillance of antimicrobial resistance. EARS-Net activities are coordinated in close collaboration with two other major surveillance networks: the European Surveillance of Antimicrobial Consumption Network (ESAC-Net) and the Healthcare-associated Infections Surveillance Network (HAI-Net). EARS-Net collaborates with the European Society of Clinical Microbiology and Infectious Diseases (ESCMID), in particular with the European Committee on Antimicrobial Susceptibility Testing (EUCAST) which is supported by ECDC/ESCMID.

The objectives of EARS-Net are:

- to collect comparable and validated AMR data;
- to analyse temporal and spatial trends of AMR in Europe;
- to provide timely AMR data that constitute a basis for policy decisions;
- to encourage the implementation, maintenance and improvement of national AMR surveillance programmes; and
- to support national systems in their efforts to improve diagnostic accuracy in the surveillance chain by offering an annual External Quality Assessment (EQA).

Since 1998, the participating laboratories have collected AMR data on over one million invasive bacterial isolates. Being the largest publicly funded system for surveillance of antimicrobial resistance in Europe, data from EARS-Net play an important role in documenting the occurrence and spread of antimicrobial resistance in Europe, and contribute to raising awareness of the problem at the political level, among public health officials, in the scientific community and with the general public. All participating countries have open access to the EARS-Net database. Public access to descriptive data (maps, graphs and tables) are also available through a web-based data query tool[iv] and more detailed analyses are presented in the annual reports and in scientific publications.

i Official Journal of the European Communities. OJ L 28, 3.2.2000, p. 50–53.

ii Official Journal of the European Union. OJ L 142, 30.4.2004, p. 1.

iii Official Journal of the European Union. OJ C 211, 18.7.2012, p. 2–5.

iv EARS-Net interactive database. Available at http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/database/Pages/database.aspx

2 Data collection and analysis

EARS-Net performs surveillance of AMR in seven bacterial pathogens of public health importance:

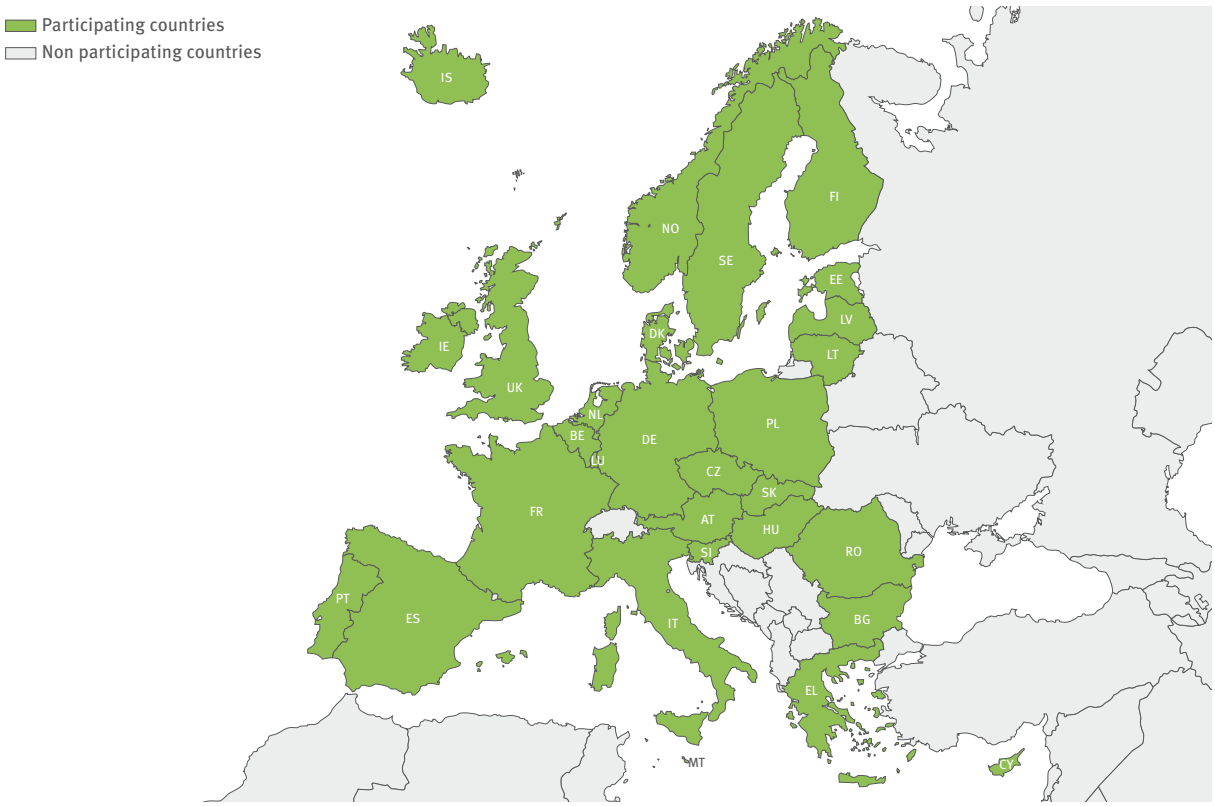
- *Streptococcus pneumoniae*
- *Staphylococcus aureus*
- *Enterococcus faecalis*
- *Enterococcus faecium*
- *Escherichia coli*
- *Klebsiella pneumoniae*
- *Pseudomonas aeruginosa*

All 27 EU Member states and two EEA countries (Norway and Iceland) reported AMR data for 2011 to EARS-Net (Figure 2.1). Only data from invasive (blood and cerebrospinal fluid) isolates are included. The panels of antimicrobial agent combinations under surveillance for each bacterium are defined in the EARS-Net Reporting Protocol[i].

Routine antimicrobial susceptibility test results are collected from clinical laboratories by the national

i EARS-Net Reporting Protocol Version 2, 2012. Available from http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Documents/2010_EARS-Net_Reporting%20Protocol.pdf

Figure 2.1: Countries contributing AMR data for 2011 to EARS-Net



AT	Austria	**FI**	Finland	**NL**	Netherlands
BE	Belgium	**FR**	France	**NO**	Norway
BG	Bulgaria	**HU**	Hungary	**PL**	Poland
CY	Cyprus	**IE**	Ireland	**PT**	Portugal
CZ	Czech Republic	**IS**	Iceland	**RO**	Romania
DE	Germany	**IT**	Italy	**SE**	Sweden
DK	Denmark	**LT**	Lithuania	**SI**	Slovenia
EE	Estonia	**LU**	Luxembourg	**SK**	Slovakia
EL	Greece	**LV**	Latvia	**UK**	United Kingdom
ES	Spain	**MT**	Malta		

representative in each participating country. National data are uploaded directly by the national data manager to a central database, TESSy, at ECDC on a yearly basis. TESSy is a web-based system for collection, validation and cleaning of data and is intended to be the single point for Member States to submit and retrieve data on all communicable diseases that are under EU surveillance. TESSy filters the uploaded records according to the list of pathogen/specimen/antimicrobial combinations included in the AMR surveillance and obtains one record per patient, organism, antimicrobial class combination and year (for details please refer to the EARS-Net Reporting Protocol). After uploading data, the national data manager receives a validation report and each country approves its own data before it is included for analysis. Please note that data presented by EARS-Net might diverge slightly from the data presented by the Member States themselves, as data cleaning routines might differ.

In addition to collection of data on AMR, additional 'reference' information from the national networks is collected through questionnaires distributed to participating laboratories and hospitals by the national contact points. Information is collected on the total number of blood culture sets processed in the laboratories, the number of hospital beds for each participating hospital, the type of hospital, the bed occupancy and the number of admissions. The national data managers receive the completed questionnaires, compile them and produce the final format suitable for uploading to TESSy. For more information on denominator data, see Annex 2 and the Country Summary Sheets.

2.1 Data analysis

For the analysis, an isolate is considered resistant to an antimicrobial agent when tested and interpreted as resistant (R) in accordance with the clinical breakpoint criteria used by the local laboratory. An isolate is considered non-susceptible to an antimicrobial agent when tested and found resistant (R) or with intermediate susceptibility (I) using the same clinical breakpoints as interpretive criteria. EARS-Net encourages the use of EUCAST breakpoints, however, results based on other interpretive criteria used by the reporting countries are accepted for the analysis.

As a general rule, data are expressed as a resistance percentage, i.e. the percentage of R isolates out of all isolates with antimicrobial susceptibility testing (AST) information on that specific organism–antimicrobial agent combination, and for some bacteria as the percentage of non-susceptible (I+R) isolates out of all isolates with the relevant information. For selected analyses, a 95% confidence interval is determined for the resistance percentage by applying an exact confidence interval for binomial data.

If fewer than 10 isolates are reported for a specific organism–antimicrobial agent combination in a country, the results for this country are not displayed on the maps presented in this report.

The statistical significance of temporal trends of antimicrobial resistance percentages by country is calculated based on data from the last four years. Countries reporting fewer than 20 isolates per year, or not providing data for all years within the considered period, are not included in the analysis. Statistical significance of trends is assessed by the Cochran–Armitage test. An additional sensitivity analysis is performed by repeating the Cochran–Armitage test only including laboratories which consistently reported for the full four-year period in order to exclude selection bias when assessing the significance of the trends.

2.2 Interpretation of the results

Interpretation of the results, both for inter-country comparison and in some cases for interpretation of national trends, should be made with caution. A number of factors might influence and introduce bias to the data, resulting in over- as well as underestimation of resistance percentages. Some of the most important potential sources of bias in EARS-Net are explained below.

Population coverage

Population coverage varies between reporting countries. Some countries report data from large national surveillance systems with a high national coverage, while other countries report data from a smaller subset of local laboratories and hospitals.

For countries only reporting data from a smaller number of hospitals and laboratories located in one specific geographical area, the sample may not be representative for the whole country. Likewise, national trends may not be representative for regional situations as pooled data could mask variations at local level.

For some countries, the population under surveillance is not constant and may change over the years due to variations in the number of participating laboratories. To control for this potential bias in trend analyses, an additional sensitivity analysis including a subset of data originating only from laboratories reporting for all the previous four years, is provided for all national trend analyses.

For detailed information on the number of reporting laboratories, characteristics of reported data and population under surveillance, see Annex 2 and Country Summary Sheets.

Sampling

EARS-Net data are exclusively based on invasive isolates from blood or cerebrospinal fluid. The clinical relevance of indicator organisms isolated from these sites is undisputable. This restriction prevents some of the inconsistencies that arise from differences in clinical case definitions, different sampling frames or heterogeneous healthcare utilisation that would otherwise confound the data analysis if isolates from all anatomical sources were accepted. However, invasive isolates may for biological reasons not be representative for

isolates of the same bacterial species from other sites, i.e. urinary tract infections, pneumonia, wound infections, etc.

Case ascertainment of patients with bloodstream infections (BSIs) is strongly linked to diagnostic habits and the frequency with which blood cultures are taken. Therefore, variations in blood culture frequency (non-differential sampling) result in an increasing uncertainty when comparing resistance percentages between different hospitals and countries. Extrapolations of EARS-Net data as a measure of BSI incidence could therefore underestimate the true value in countries with low blood culture frequency.

Differential sampling can occur if blood cultures are typically only performed after empirical treatment shows no adequate therapeutic response. Predictably, this will lead to an overestimation of the percentage resistance by not including susceptible BSI isolates from the denominator.

For detailed information on national blood culture frequency, see Annex 2.

Laboratory routines and capacity

The use of guidelines for clinical breakpoints varies between countries in Europe, and in some instances even between laboratories in the same country. As a result the interpretation of AST results may vary, at least for resistance mechanisms producing MICs close to the breakpoints. In addition, the use of microbiological breakpoints may change over time, when breakpoint protocols are updated or changed. As data on quantitative measures (i.e. zone diameters in disk diffusion tests or MIC values) are not provided by all participating laboratories, only the reported S, I, and R results are considered for the analyses.

The ability of the laboratory to identify the microorganism and its associated antimicrobial susceptibility pattern may differ. All laboratories providing data for EARS-Net are offered participation in an annual External Quality Assessment (EQA) exercise to assess the reliability of the laboratory test results.

For more information on the EARS-Net EQA and laboratory performance, see Annex 1.

3 Demographic characteristics of cases of invasive gram-negative infections in Europe

Experiences from EARSS/EARS-Net 2005–2011

3.1 Introduction

Gram-negative bacteria (GNB) are a frequent cause of serious infections including bloodstream infections (BSIs)[1]. Antimicrobial-resistant GNB have become an important clinical and public health issue, having a significant impact on morbidity, mortality and health-related costs[2–6]. Trends reported from EARSS/EARS-Net have shown a continuous increase in the percentages of antimicrobial-resistant GNB in many countries, indicating that the rise of resistant GNB in Europe is becoming a serious public health problem that requires urgent and concerted action. Antibiotic treatment options for multi-drug-resistant GNB are often very limited and finding an appropriate drug is an increasing challenge since very few new antibiotics are expected to enter the market as the older classes lose their efficacy[7].

An understanding of the risk factors associated with antimicrobial-resistant GNB is essential to guide interpretation of surveillance data and design effective control programmes, as antimicrobial-resistant GNB are reported to vary depending on geography, origin of isolate and type of population under surveillance[8–12]. Data from EARSS/EARS-Net provide an important source of information on GNB in Europe, including information from over 471 000 GNB isolates from 29 EU/EEA countries collected over seven years. Traditionally, data from EARS-Net are presented by their temporal and spatial aspects and are not routinely analysed by the demographic characteristics of the cases. The exception is the country summary sheets provided in the annual EARS-Net report presenting isolates by age group, gender and hospital department. However, annual national data in most cases do not cover a sufficient number of isolates to determine any significant differences in data stratified by major demographic characteristics.

Here we used pooled EARSS/EARS-Net data from 2005 to 2011 to describe general demographic characteristics of GNB infection cases reported to the network, and investigated demographic differences in resistance to major antimicrobial classes and for combined resistance. This provides previously unpublished information on antimicrobial-resistant GNB epidemiology in Europe.

3.2 Material and methods

Data for the three GNB included in EARS-Net (*Klebsiella pneumoniae*, *Escherichia coli* and *Pseudomonas aeruginosa*) reported from 2005 to 2011 were extracted from the EARS-Net (formerly EARSS) database at ECDC. Data were analysed by bacterial species and stratified according to patient's age, gender, admission status and hospital department type. For age, data were grouped in four age strata: 0 to 4 years; 5 to 19 years; 20 to 64 years and 65 years or older. Gender strata were female and male. Admission status was stratified according to reported inpatient and outpatient status at the time the isolates were obtained. Hospital department type was stratified as intensive care units (ICUs) (for isolates reported obtained from patients in adult or paediatric ICUs) and other, non-ICU departments (including patients from internal medicine, paediatric, surgery, oncology, obstetrics/gynaecology, emergency, urology, infectious disease and other departments).

Reporting completeness differed for the variables. Age information was missing for 7% of all cases, with one country (Greece) providing age information for less than half of the cases; gender information was missing for 7% of all cases with one country (Greece) providing gender information for less than half of their cases; admission status was missing for 15% of all cases with three countries (Finland, Iceland and Ireland) providing this information for less than half of their cases; and information on hospital department was missing for 26% of the cases with six countries (Belgium, Finland, Ireland, Luxembourg, Netherlands and United Kingdom) reporting hospital department for less than half of their cases.

Significant differences in selected demographic characteristics between two groups were determined by Chi^2-test, and a p-value < 0.05 was considered statistically significant.

Mean percentages of AMR during the study period including a 95% confidence interval (CI) were calculated per bacterial species for the total number of isolates, as well as for each demographic characteristic included in the study. For *E. coli* and *K. pneumoniae*, resistance to third-generation cephalosporins and combined resistance (i.e. resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides) were included, and for *P. aeruginosa* resistance to carbapenems and combined resistance (i.e. resistance to three or more of piperacillin±tazobactam, fluoroquinolones, ceftazidime, aminoglycosides and carbapenems) were included in the analysis.

3.3 Results

General demographic characteristics of reported isolates

A total of 471596 invasive isolates were included in the study, of which *E. coli* were the majority, accounting for 344700 (73%) isolates, followed by *K. pneumoniae* at 74985 isolates (16%) and 51911 (11%) *P. aeruginosa* isolates. The number of isolates for which information on age and gender was missing was higher for *K. pneumoniae* and *P. aeruginosa* than *E. coli*.

As shown in Table 3.1, the age distribution was skewed towards the elderly population (aged 65 years or older) for all included bacterial species. The highest percentage of isolates from the elderly was reported for *E. coli* (64%) and this was also the bacterium with the lowest percentage of isolates from young children (0 to 4 years). *Escherichia coli* were more frequent in females whereas *K. pneumoniae* and *P. aeruginosa* were more frequent in males.

Inpatients represented the majority of cases for all bacteria, but the percentage was significantly lower for *E. coli* compared to the other two GNB ($p < 0.001$). The percentage of ICU patients was also significantly lower for *E. coli* than for the two other GNB ($p < 0.001$).

Although the annual number of reported isolates increased for all three GNB over the seven-year reporting period, the distribution of GNB by age, gender, admission status and hospital departments has not changed considerably over the years.

Demographic characteristics of antimicrobial-resistant GNB

Age

For resistance to third-generation cephalosporins and combined resistance of *E. coli*, resistance percentages were significantly higher for the two oldest age groups than for patients aged four years or younger. In contrast, percentages of *K. pneumoniae* that were resistant to third-generation cephalosporins decreased as age increased i.e. were significantly higher among the young children and significantly lower among patients aged 65 years or older compared with other age groups. For combined resistance of *K. pneumoniae*, a similar pattern with the highest level of resistance in the youngest age group and the lowest level of resistance among the oldest age group was evident, with statistically lower resistance percentages for the oldest age stratum than for other age groups (Table 3.2).

For *P. aeruginosa*, the elderly (age ≥65 years) had significantly lower resistance percentages for both resistance to carbapenems and combined resistance than any other age group. The age group 20–64 years showed a significantly higher percentage of combined resistance than the other age groups, but there was no significant difference for carbapenem resistance (Table 3.3).

Gender

For both *E. coli* and *K. pneumoniae*, isolates from male patients had significantly higher resistance percentages (between 20 and 35% higher) than isolates from females for both studied resistance groups (Table 3.2).

For *P. aeruginosa*, no significant differences could be noted between females and males (Table 3.3).

Admission status and hospital department

For all three bacterial species, inpatients had significantly higher percentages of resistance to the studied antimicrobial classes than outpatients. The differences between in- and outpatients were especially large for *K. pneumoniae* and *P. aeruginosa* with resistance percentages two to four times higher, while the differences for *E. coli* were more modest although still significant (Tables 3.2, 3.3).

Table 3.1: Characteristics of patient data linked to invasive GNB isolates reported to EARSS/EARS-Net during the period 2005–2011

	E. coli	*K. pneumoniae*	*P. aeruginosa*
Total number of reported isolates	344 700 (73%)	74 985 (16%)	51 911 (11%)
Age			
0 to 4 years	7 909 (2%)	2 708 (4%)	1 446 (3%)
5 to 19 years	3 530 (1%)	771 (1%)	853 (2%)
20 to 64 years	98 006 (28%)	23 716 (32%)	17 458 (34%)
65 years or older	220 024 (64%)	38 212 (51%)	25 314 (49%)
Information missing	15 231 (4%)	9 578 (13%)	6 840 (13%)
Gender			
Male	152 025 (44%)	38 898 (52%)	29 018 (56%)
Female	175 980 (51%)	26 928 (36%)	16 225 (31%)
Information missing	16 695 (5%)	9 159 (12%)	6 668 (13%)
Admission status			
Inpatient	242 424 (70%)	60 105 (80%)	42 923 (83%)
Outpatient	46 081 (13%)	5 874 (8%)	3 095 (8%)
Information missing	56 195 (16%)	9 006 (12%)	5 893 (11%)
Hospital department			
ICU	23 915 (7%)	15 031 (20%)	12 940 (25%)
Other departments	224 971 (65%)	43 929 (59%)	27 040 (52%)
Information missing	95 814 (28%)	16 025 (21%)	11 931 (23%)

Among inpatients, isolates from ICU patients were significantly more likely to be resistant to the studied antimicrobial classes than isolates from other departments (non-ICU patients). The differences in resistance percentage between ICU and non-ICU patients were less prominent for *E. coli* than *K. pneumoniae* and *P. aeruginosa*, but were significant for all three bacteria (Tables 3.2, 3.3).

3.4 Discussion

This study is based on a unique dataset containing information from a large number of GNB isolates collected from 29 European countries over a seven-year period. For the first time, we present the demographic characteristics of cases of invasive GNB infection as reported to EARSS/EARS-Net, highlighting differences in the epidemiological data linked to the isolates of *E. coli*, *K. pneumoniae* and *P. aeruginosa* in Europe.

The rank order of the bacteria included in this study was similar to that which has been reported elsewhere[4,13–15] with the majority (70%) of the isolates being *E. coli*. There was a significant difference between the demographic profile of cases with *E. coli* BSI and cases with BSI caused by *K. pneumoniae* or *P. aeruginosa*; a higher percentage of isolates from the elderly, a majority of female patients and a lower percentage of isolates from inpatients and from ICU patients. Although data from EARSS/EARS-Net do not provide sufficient information to determine the origin of the infection, these results may partly be explained by previously reported differences in the aetiology of invasive *E. coli* infections and of *K. pneumoniae* and *P. aeruginosa* infections. In several studies, *E. coli* has more frequently been associated with community-acquired BSI than other GNB[16] and was more often associated with a urinary tract source[17], especially in female patients[18]. This is in contrast to observations for invasive isolates of *K. pneumoniae* and *P. aeruginosa*

Table 3.2: Percentage (%) of isolates resistant to third-generation cephalosporins (3GC R) and combined resistance (combined R) (resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides) for all cases and per demographic characteristic in invasive isolates of *E. coli* and *K. pneumoniae* reported to EARSS/EARS-Net during the period 2005–2011 (95% CI given in parenthesis)

	E. coli		*K. pneumoniae*	
	3GC R	Combined R	3GC R	Combined R
All cases	6.7 (6.6-6.8)	2.9 (2.8-2.9)	35.3 (33.5-37.2)	17.5 (17.2-17.8)
Age				
0 to 4 years	5.5 (5.0-6.1)	1.5 (1.2-1.8)	35.3 (33.5-37.2)	15.4 (14.0-16.8)
5 to 19 years	5.7 (4.9-6.5)	2.1 (1.6-2.7)	24.5 (21.4-27.8)	13.6 (11.2-16.3)
20 to 64 years	6.6 (6.4-6.7)	2.8 (2.7-2.9)	23.1 (22.5-23.6)	15.7 (15.2-16.2)
65 years or older	6.5 (6.4-6.6)	2.7 (2.7-2.8)	17.0 (16.7-17.4)	11.0 (10.6-11.1)
Gender				
Male	7.9 (7.7-8.0)	3.4 (3.3-3.5)	22.3 (21.9-22.7)	14.6 (14.2-15.0)
Female	5.4 (5.3-5.5)	2.2 (2.1-2.2)	17.8 (17.3-18.3)	11.1 (10.7-11.5)
Admission status				
Inpatient	7.1 (7.0-7.2)	3.0 (3.0-3.1)	29.0 (28.7-29.4)	20.0 (19.7-20.4)
Outpatient	5.1 (4.9-5.3)	2.1 (2.0-2.3)	8.2 (7.5-9.0)	5.0 (4.4-5.6)
Hospital department				
ICU	9.8 (9.4-10.2)	3.9 (3.6-4.1)	51.7 (50.9-52.5)	37.1 (36.3-37.9)
Other department	6.4 (6.4-6.5)	2.8 (2.7-2.9)	18.9 (18.6-19.2)	12.3 (12.0-12.6)

Table 3.3: Percentage (%) resistance to carbapenems and combined resistance (resistance to three or more antibiotic classes among piperacillin–tazobactam, ceftazidime, aminoglycosides and carbapenems) for all cases and per demographic characteristic in invasive isolates of *P. aeruginosa* reported to EARSS/EARS-Net during the period 2005–2011 (95% CI given in parenthesis)

	P. aeruginosa	
	Carbapenem R	Combined resistance
All cases	18.8 (18.5-19.1)	15.6 (15.3-15.9)
Age		
0 to 4 years	17.2 (15.3-19.3)	11.4 (9.7-13.0)
5 to 19 years	17.1 (14.5-19.8)	11.1 (9.0-13.3)
20 to 64 years	19.7 (19.1-20.4)	15.5 (15.0-16.0)
65 years or older	11.5 (11.1-11.9)	9.5 (9.2-9.9)
Gender		
Male	15.5 (15.1-15.9)	12.5 (12.1-12.9)
Female	14.8 (14.3-15.4)	11.6 (11.1-12.1)
Admission status		
Inpatient	20.8 (20.4-21.2)	17.5 (17.2-17.9)
Outpatient	6.7 (5.8-7.7)	4.4 (3.7-5.1)
Hospital department		
ICU	32.5 (31.7-33.3)	27.9 (27.1-28.7)
Other department	14.1 (13.7-14.5)	11.5 (11.2-11.8)

which have been reported to originate more frequently from healthcare-associated infections and from patients in ICU[14] where BSIs with GNB often originate from the respiratory or gastrointestinal tract[17–20].

For all GNB and all resistance types included in the study, isolates from inpatients had higher resistance levels than those from outpatients, and isolates from ICU patients had significantly higher resistance percentages than isolates from patients from other departments. These results are hardly surprising and support previous conclusions highlighting risk factors for transmission of resistant bacteria in the hospital environment. High antibiotic pressure, frequent use of invasive devices and the challenge of maintaining a high standard of infection control all contribute to increase the risk of patients acquiring a healthcare-associated infection with resistant bacteria[20].

Our results also revealed age- and gender-related differences between resistance percentages. While these differences were less prominent for *E. coli* than *K. pneumoniae* and *P. aeruginosa*, they could be noted for all three bacteria. Interestingly, the age group where resistance percentages were the highest differed between bacteria. For *K. pneumoniae* and *P. aeruginosa*, resistance percentages were lower in isolates from the elderly (age ≥65 years) than in those from other age groups, whereas for *E. coli* resistance percentages were higher among isolates from adults and the elderly than from children. These differences are difficult to explain, but may be attributed to differences in the types of infection caused by the bacteria as well as age-related differences in risk factors such as antimicrobial use and exposure to the healthcare environment. A more in-depth analysis including additional clinical information is required in order to properly determine the role of the patient's age in resistance percentages for the different bacteria.

Providing representative population estimates is a challenge for any surveillance system[21,22]. The EARSS/EARS-Net inclusion criteria address some of the potential threats to data validity by only accepting information from invasive isolates and by excluding duplicate reports from the same patient and year. By pooling information from a seven-year period, the large number of observations allowed for analysis of data by different demographic strata. However, pooling national surveillance data to provide European estimates will increase the risk of bias caused by inter-country differences in population coverage, methods for data collection and specimen processing. As the population coverage for the countries participating in EARS-Net varies considerably, individual countries will contribute differently to the crude European estimate. In addition, the percentage of missing information for the demographic variables differed both between countries and between bacteria. The percentages of isolates missing information on age and gender were considerably higher for *K. pneumoniae* and *P. aeruginosa* than for *E. coli*. Although this may partly influence the observed differences in age and gender distribution between the bacteria, it is unlikely that it would fully explain the observed demographic differences.

In conclusion, documenting population-specific differences in resistance percentages and trends is important to enable identification of high-risk groups and to formulate policies on screening, prevention and control of AMR. Data from EARSS/EARS-Net indicate that there are significant differences in the demographic profiles of cases with invasive GNB infections in Europe, both for the GNB involved, and for the percentages of resistance to important antimicrobials including combined resistance. However, due to the ecological nature of EARSS/EARS-Net data, our results should be interpreted with caution, and we encourage additional studies based on data with more extensive clinical information to further explore these differences.

4 Antimicrobial resistance in Europe

4.1 *Escherichia coli*

4.1.1 Clinical and epidemiological importance

Escherichia coli is the gram-negative rod most frequently isolated from blood cultures. It is the most frequent cause of bacteraemia, community- and hospital-acquired urinary tract infections, is associated with spontaneous and post-surgical peritonitis and with skin and soft tissue infections of polymicrobial aetiology, causes neonatal meningitis and is one of the leading causative agents in food-borne infections worldwide.

4.1.2 Resistance mechanisms

In *E. coli*, resistance to beta-lactams is mostly due to production of beta-lactamases, which hydrolyse the beta-lactam ring of beta-lactam antimicrobials, which is crucial for inhibition of the penicillin-binding protein (PBP) targets. Resistance to broad-spectrum penicillins, such as ampicillin or amoxicillin, is usually conferred by plasmid coded beta-lactamases mainly of the TEM type and to a lesser extent of the SHV type, (whereby TEM-1 accounts for up to 60% of aminopenicillin resistance), while resistance to third-generation cephalosporins is mostly conferred by extended-spectrum beta-lactamases (ESBLs). The first ESBLs spreading in *E. coli* were variants of the TEM or SHV enzymes in which single or multiple aminoacid substitutions expand their hydrolysing ability to include third-generation cephalosporins (in this report referring to cefotaxime, ceftriaxone and ceftazidime), fourth-generation cephalosporins and monobactams. During the past decade, however, these enzymes have largely been replaced by the CTX-M-type ESBLs, which are now the most common ESBLs in *E. coli*. Most ESBLs can be inhibited by beta-lactamase inhibitors such as clavulanic acid, sulbactam or tazobactam. More than 250 ESBL variants are known to date. An important factor in their global dominance is the wide dissemination of particular plasmids or bacterial clones producing CTX-M-type ESBLs (e.g. CTX-M-15). Other enzymes affecting the susceptibility to third-generation cephalosporins include plasmid-encoded variants derived from some chromosomal AmpC-type beta-lactamases. CMY-2 is the most widespread enzyme belonging to this group, which is still less common than ESBLs in *E. coli* in Europe, but frequently seen in the United States. An important threat that will require close surveillance in the future is the emergence of carbapenem resistance in *E. coli*, mediated by metallo-beta-lactamases (such as the VIM or IMP enzymes, or the emerging NDM enzyme) or serine-carbapenemases (such as the KPC enzymes), providing resistance to most or all available beta-lactam

Figure 4.1: *Escherichia coli*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by country, EU/EEA countries, 2011

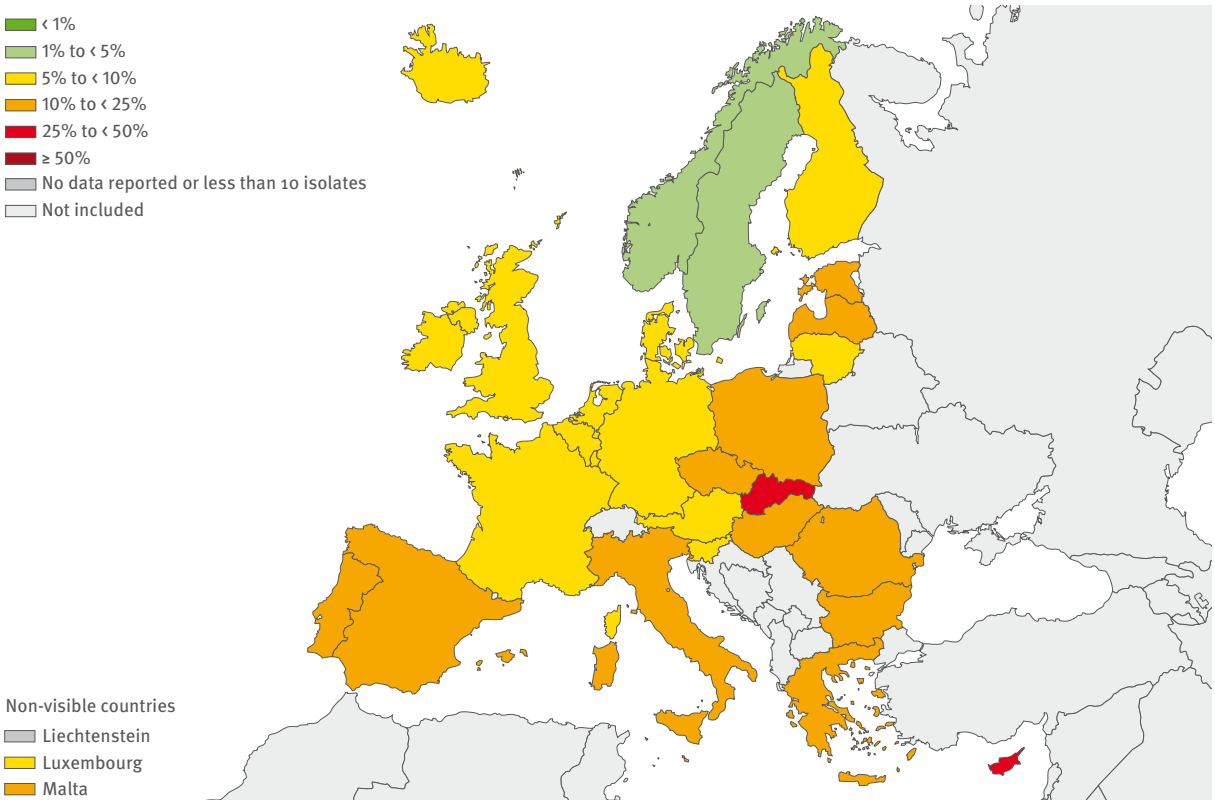


Figure 4.2: *Escherichia coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones, by country, EU/EEA countries, 2011

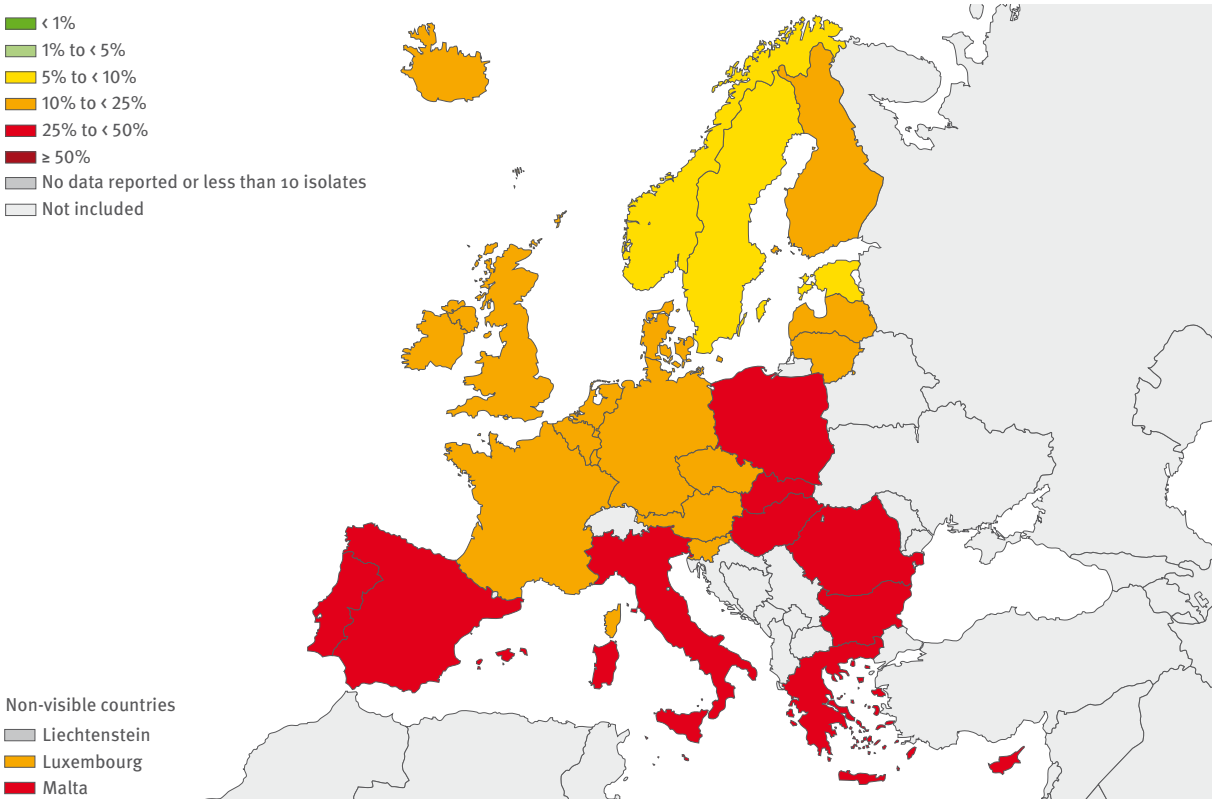
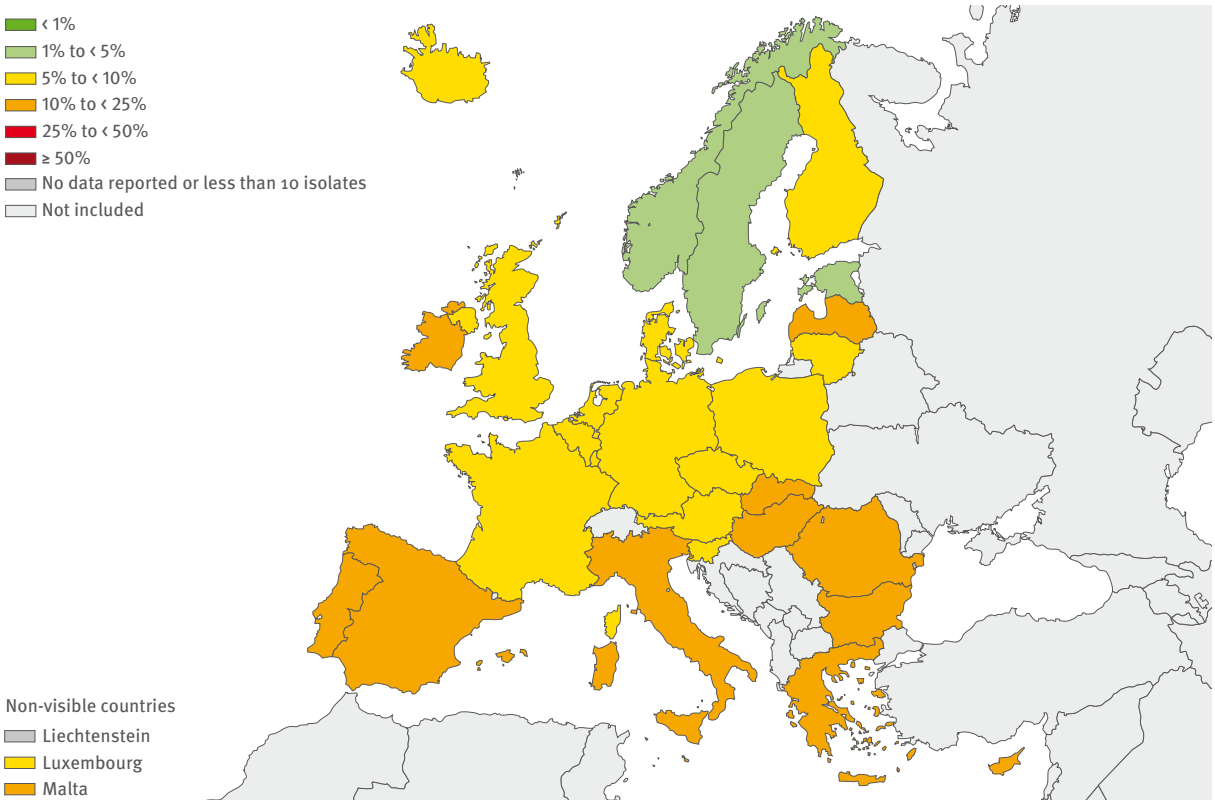


Figure 4.3: *Escherichia coli*: percentage (%) of invasive isolates with resistance to aminoglycosides, by country, EU/EEA countries, 2011



agents. Another growing family of ESBLs comprises the OXA-type enzymes that confer resistance to ampicillin and cefalotin and are characterised by their high hydrolytic activity against oxacillin and cloxacillin and the fact that they are poorly inhibited by clavulanic acid. This family also includes some enzymes with carbapenemase activity (e.g. OXA-48), which have recently emerged in *E. coli* and other enterobacteriaceae and confer reduced susceptibility to carbapenems and resistance to penicillins, but not to the expanded-spectrum cephalosporins. Increasingly common is also the finding of *E. coli* strains which produce multiple beta-lactamases.

Fluoroquinolones interact with DNA gyrase and topoisomerase IV, which are enzymes that regulate conformational changes in the bacterial chromosome during replication and transcription. This interaction leads to the irreversible inhibition of the enzyme activity followed by DNA fragmentation and eventually to cell death. Resistance to fluoroquinolones arises through stepwise mutations in the coding regions of the gyrase subunits (gyrA and gyrB) and DNA topoisomerase IV (parC). Accumulation of mutations in several of these genes increases the MIC in a stepwise manner. Low-level resistance to fluoroquinolones may also arise through changes in outer membrane porins or from upregulation of efflux pumps, resulting in lower outer membrane permeability and higher efflux, respectively. In recent years, several plasmid-mediated quinolone resistance mechanisms have also been identified, including the Qnr proteins, which protect DNA topoisomerases from quinolone binding, the AAC(6')-Ib-cr enzyme, which inactivates some fluoroquinolones by acetylation, and the QepA efflux pump, which effluxes hydrophilic quinolones. These mechanisms are a concern because this type of resistance is transferable and because of their frequent association with CTX-M and CMY-type enzymes inactivating third-generation cephalosporins. Additionally they are believed to increase the risk of chromosomal mutations.

Aminoglycosides block protein synthesis by binding to the ribosomes, which are involved in the translation of RNA into proteins, and are also able to damage the outer membrane of gram-negative rods. Resistance to aminoglycosides can be due to targeted modification (methylation) of the large ribosomal subunit, which excludes aminoglycoside molecules, or by aminoglycoside-modifying enzymes that acetylate, adenylate or phosphorylate their target molecules and thereby neutralise the biological effect of aminoglycosides. Of particular concern is ArmA 16S that confers pan-resistance to aminoglycosides, and is frequently accompanying carbapenemases.

4.1.3 Results

Aminopenicillins

- For 2011, 28 countries reported 57920 isolates, of which 32110 (55.4%) were resistant to

Table 4.1: *Escherichia coli*: number and percentage of invasive isolates resistant to aminopenicillins, third-generation cephalosporins, fluoroquinolones, aminoglycosides and combined resistance*, including 95% confidence intervals (95% CI), by country, EU/EEA countries, 2011

Country	Aminopenicillins		Third-gen. cephalosporins		Fluoroquinolones		Aminoglycosides		Combined resistance	
	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)
Austria	3148	50.3 (49-52)	3160	9.1 (8-10)	3162	22.3 (21-24)	3144	7.4 (7-8)	3121	2.6 (2-3)
Belgium	3507	58.7 (57-60)	3985	6.0 (5-7)	3549	21.5 (20-23)	3831	9.3 (8-10)	3331	1.4 (1-2)
Bulgaria	152	60.5 (52-68)	179	22.9 (17-30)	179	30.2 (24-37)	179	17.3 (12-24)	179	10.1 (6-15)
Cyprus	134	77.6 (70-84)	138	36.2 (28-45)	137	47.4 (39-56)	138	23.9 (17-32)	137	18.2 (12-26)
Czech Republic	2683	60.7 (59-63)	2684	11.4 (10-13)	2682	23.5 (22-25)	2674	8.8 (8-10)	2667	3.7 (3-4)
Denmark	3638	47.9 (46-50)	2532	8.5 (7-10)	3583	14.1 (13-15)	3638	6.4 (6-7)	2529	3.0 (2-4)
Estonia	0	.	90	12.2 (6-21)	312	9.9 (7-14)	314	4.8 (3-8)	89	1.1 (0-6)
Finland	1826	36.3 (34-39)	2419	5.1 (4-6)	2420	10.8 (10-12)	2420	5.3 (4-6)	2419	2.7 (2-3)
France	8784	55.1 (54-56)	8479	8.2 (8-9)	8694	17.9 (17-19)	8742	7.9 (7-8)	8428	2.6 (2-3)
Germany	3638	52.3 (51-54)	3642	8.0 (7-9)	3636	23.7 (22-25)	3645	7.6 (7-9)	3631	3.6 (3-4)
Greece	1297	54.5 (52-57)	1435	14.9 (13-17)	1433	26.6 (24-29)	1434	16.8 (15-19)	1431	10.8 (9-13)
Hungary	991	64.7 (62-68)	1224	15.1 (13-17)	1213	31.2 (29-34)	1226	14.8 (13-17)	1209	8.3 (7-10)
Iceland	129	48.1 (39-57)	130	6.2 (3-12)	121	14.0 (8-22)	129	6.2 (3-12)	120	0.8 (0-5)
Ireland	2118	69.5 (68-72)	2166	9.0 (8-10)	2153	22.9 (21-25)	2158	10.2 (9-12)	2148	3.6 (3-4)
Italy	1530	67.1 (65-69)	1870	19.8 (18-22)	1899	40.5 (38-43)	1985	18.3 (17-20)	1745	10.3 (9-12)
Latvia	130	54.6 (46-63)	132	15.9 (10-23)	131	16.8 (11-24)	132	11.4 (7-18)	131	9.2 (5-15)
Lithuania	383	47.8 (43-53)	385	7.0 (5-10)	381	12.9 (10-17)	382	9.7 (7-13)	378	2.4 (1-4)
Luxembourg	353	52.1 (47-57)	353	8.2 (6-12)	353	24.1 (20-29)	354	8.2 (6-12)	353	2.8 (1-5)
Malta	219	53.0 (46-60)	219	12.8 (9-18)	219	32.0 (26-39)	219	15.5 (11-21)	219	9.6 (6-14)
Netherlands	4425	48.5 (47-50)	4408	5.7 (5-6)	4427	14.3 (13-15)	4431	7.8 (7-9)	4400	2.2 (2-3)
Norway	2617	39.1 (37-41)	2523	3.6 (3-4)	2505	9.0 (8-10)	2470	4.1 (3-5)	2259	1.2 (1-2)
Poland	934	62.0 (59-65)	938	11.7 (10-14)	1141	27.3 (25-30)	1171	8.4 (7-10)	902	4.0 (3-5)
Portugal	1963	56.5 (54-59)	1901	11.3 (10-13)	1917	27.2 (25-29)	1962	16.1 (14-18)	1891	7.5 (6-9)
Romania	22	68.2 (45-86)	91	22.0 (14-32)	46	30.4 (18-46)	46	19.6 (9-34)	46	10.9 (4-24)
Slovakia	608	68.6 (65-72)	738	31.0 (28-35)	737	41.9 (38-46)	738	17.9 (15-21)	737	12.9 (11-16)
Slovenia	1002	53.9 (51-57)	1002	8.8 (7-11)	1002	20.7 (18-23)	1002	9.8 (8-12)	1002	4.1 (3-6)
Spain	5592	65.6 (64-67)	5600	12.0 (11-13)	5597	34.5 (33-36)	5603	14.8 (14-16)	5594	4.9 (4-6)
Sweden	1023	34.8 (32-38)	3939	3.0 (3-4)	3295	7.9 (7-9)	3203	3.7 (3-4)	2844	1.0 (1-1)
United Kingdom	5074	62.8 (61-64)	5182	9.6 (9-10)	5564	17.5 (17-19)	5661	8.2 (7-9)	5005	3.6 (3-4)

* Combined resistance defined as being resistant to third-generation cephalosporins, fluoroquinolones and aminoglycosides.

Table 4.2: *Escherichia coli*: number of invasive isolates resistant to third-generation cephalosporins (3GCREC) and percentage of extended spectrum beta-lactamase (ESBL)-positive among these isolates, as ascertained by the participating laboratories, EU/EEA countries, 2011

Country	Number of laboratories	Number of 3GCREC	%ESBL
Austria	27	237	91.1
Bulgaria	12	30	93.3
Czech Republic	42	305	89.5
Denmark	3	45	71.1
Estonia	5	11	100
France	16	99	83.8
Germany	12	190	92.1
Hungary	9	44	100
Ireland	26	189	82
Latvia	5	21	90.5
Lithuania	8	27	100
Luxembourg	5	29	96.6
Poland	33	98	85.7
Portugal	14	159	97.5
Slovakia	7	154	83.1
Slovenia	9	88	94.3
Spain	26	381	88.5

Only data from laboratories consistently reporting the ESBL test results for all isolates identified as resistant to third-generation cephalosporins and from countries with at least 10 of such isolates were selected for the analysis.

aminopenicillins. The number of isolates with relevant AST information reported per country ranged from 22 to 8784 (Table 4.1).

- The percentages of resistant isolates in the reporting countries ranged from 34.8% (Sweden) to 77.6% (Cyprus). Seven countries reported 25-50%, while the remaining 21 countries reported resistant percentages above 50% (Table 4.1).
- Trends for the period 2008–2011 were calculated for 27 countries. Significantly increasing trends were observed for eight countries (Belgium, Cyprus, Denmark, Greece, Hungary, Italy, Spain and Sweden). For Belgium, Italy and Sweden the trends were not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.4).
- Significantly decreasing trends were observed for two countries (Germany and Lithuania); however, these trends were not significant when considering only laboratories reporting consistently for all four years (Figure 4.4).

Third-generation cephalosporins

- For 2011, 29 countries reported 61544 isolates, of which 5619 (9.1%) were resistant to third-generation cephalosporins. The number of isolates with relevant AST information reported per country ranged from 90 to 8479 (Table 4.1).
- The percentages of resistant isolates in the reporting countries ranged from 3.0% (Sweden) to 36.2% (Cyprus). Two countries reported resistance percentages below 5%, 13 countries reported 5-10%, 12 countries reported 10-25%, and two countries reported above 25% (Table 4.1 and Figure 4.5).
- Trends for the period 2008–2011 were calculated for 28 countries. Significant increasing trends were observed in 18 of 28 countries. For three countries (Italy, the Netherlands, and Poland), the trends did not remain significant when considering only data from laboratories reporting consistently for all four years (Figure 4.5).
- None of the 28 reporting countries had decreasing trends of resistance to third-generation cephalosporins over the last four years (Figure 4.5).

Extended-spectrum beta-lactamase (ESBL)

- Among *E. coli* isolates resistant to third-generation cephalosporins, a large percentage was ascertained as ESBL-positive by the participating laboratories in 2011. Fourteen of 17 countries reported between 85% and 100% ESBL-positive isolates among isolates resistant to third-generation cephalosporins (Table 4.2).

Fluoroquinolones

- For 2011, 29 countries reported 62 488 isolates of which 13 075 (20.9%) were resistant to fluoroquinolones. The number of isolates with relevant AST information reported by the countries ranged from 46 to 8 694 (Table 4.1).
- The percentages of resistant isolates in the reporting countries ranged from 7.9% (Sweden) to 47.4% (Cyprus). Three countries reported resistance percentages below 10%, 15 countries reported 10-25% and 11 countries reported above 25% (Table 4.1 and Figure 4.2)
- Trends for the period 2008–2011 were calculated for 28 countries. Significantly increasing trends were observed for 11 countries. For Italy and Poland, these trends were not significant when considering only data from laboratories reporting consistently during all four years (Figure 4.6).
- Significantly decreasing trends were observed for the Czech Republic and Sweden; however, the trends for these two countries were not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.6).

Aminoglycosides

- For 2011, 29 countries reported 63 031 isolates of which 5 867 (9.3%) were resistant to aminoglycosides. The number of isolates with relevant AST information reported by the countries ranged from 46 to 8 742 (Table 4.1).
- The percentages of resistant isolates in the reporting countries ranged from 3.7% (Sweden) to 23.9% (Cyprus). Three countries reported resistance percentages below 5%, 14 countries reported 5-10%, 12 countries reported above 10% (Table 4.1 and Figure 4.3).
- Trends for the period 2008–2011 were calculated for 28 countries. Significantly increasing trends were

Table 4.3: *Escherichia coli*: overall resistance and resistance combinations among invasive isolates tested against aminopenicillins, fluoroquinolones, third-generation cephalosporins and aminoglycosides (n=54 338), EU/EEA countries, 2011

Resistance pattern	Number of isolates	% of total
Fully susceptible	22 586	41.6
Single resistance (to indicated drug classes)		
Total (all single resistance)	**19 293**	**35.5**
Aminopenicillins	17 954	33
Fluoroquinolones	1 236	2.3
Aminoglycosides	103	0.2
Resistance to two classes of antimicrobial drugs		
Total (all two classes combinations)	**6 457**	**11.9**
Aminopenicillins + fluoroquinolones	4 610	8.5
Aminopenicillins + third-generation cephalosporins	964	1.8
Aminopenicillins + aminoglycosides	797	1.5
Fluoroquinolones + aminoglycosides	86	0.2
Resistance to three classes of antimicrobial drugs		
Total (all three classes combinations)	**3 864**	**7.1**
Aminopenicillins + fluoroquinolones + aminoglycosides	1 867	3.4
Aminopenicillins + third-generation cephalosporins + fluoroquinolones	1 796	3.3
Aminopenicillins + third-generation cephalosporins + aminoglycosides	201	0.4
Resistance to four classes of antimicrobial drugs		
Aminopenicillins + third-generation cephalosporins + fluoroquinolones + aminoglycosides	2 138	3.9

Only data from isolates tested against all four antimicrobial classes were included in the analysis.

observed for 11 countries. For Belgium, Hungary, Italy and Portugal the trends did remain significant when considering only data from laboratories consistently reporting for all four years (Figure 4.7).

- A significantly decreasing trend of aminoglycoside resistance was observed only for one country (Bulgaria) (Figure 4.7).

Carbapenems

- For 2011, 28 countries reported 59 326 isolates, of which 25 (0.04%) were resistant to carbapenems. The number of isolates with relevant AST information reported by the countries ranged from 1 to 8 503. Eleven countries reported one or more resistant isolate(s) in 2011. The majority of the resistant isolates (10 isolates; 40%) were reported by Greece.

Combined resistance

- For 2011, 29 countries reported 58 945 *E. coli* isolates tested for resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides. The number of isolates with relevant AST information reported by the countries ranged from 46 to 8 428 (Table 4.1).
- The percentage of isolates with combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides) reported by the countries ranged from 0.8% (Iceland) to 18.2% (Cyprus). One country reported a resistance percentage below 1%, 18 countries reported 1–5%, four countries reported 5–10%, and six countries reported above 10% (Table 4.1 and Figure 4.8).
- Trends for the period 2008–2011 were calculated for 28 countries. Significantly increasing trends were observed for 13 countries. For Belgium, Italy, the Netherlands and Poland, the trends did not remain significant when considering only data from laboratories reporting consistently for all four years (Figure 4.8).
- Significantly decreasing trends were observed for Bulgaria and Malta. For Bulgaria, the trend did not remain significant when considering only data from laboratories reporting consistently for all four years.
- More detailed information on the most frequent resistance phenotypes in *E. coli* is presented in Table 4.3.

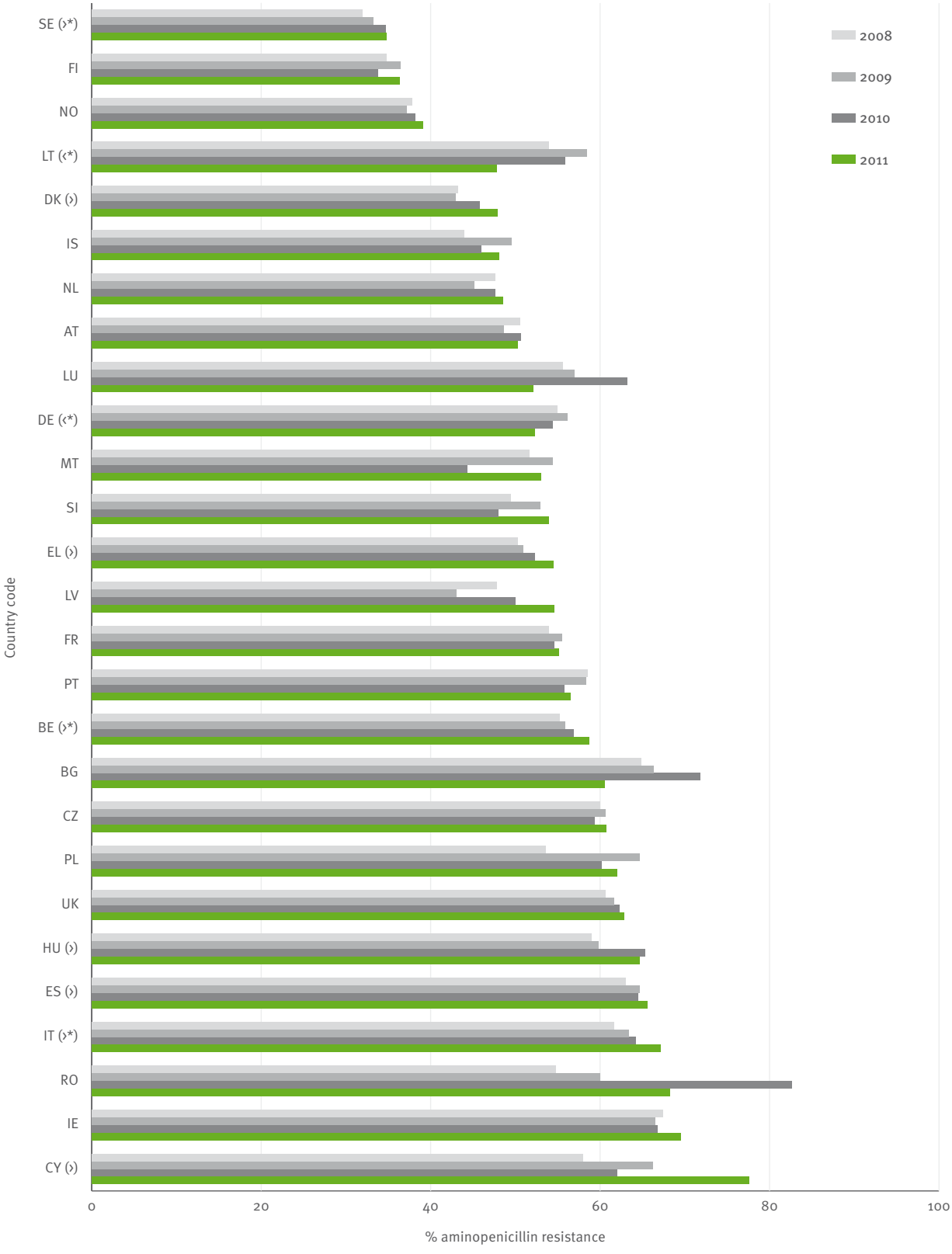
4.1.4 Discussion and conclusions

Antimicrobial resistance in *E. coli* requires close attention as the percentages of isolates resistant to commonly used antimicrobials continue to increase throughout Europe. Especially worrisome is the increase of resistance to third-generation cephalosporins and combined resistance to at least three antimicrobial classes, for which many countries reported significantly increasing trends during the period 2008–2011.

Although EARS-Net data on ESBL production remain incomplete, a large percentage of third-generation cephalosporin-resistant *E. coli* was reported as ESBL-positive. Presence of ESBL production and combined resistance is a serious public health concern since it severely limits the number of treatment alternatives for patients with life-threatening infections. In addition, increasing combined resistance and spread of ESBL may lead to increased use of carbapenems, favouring the further dissemination of carbapenemase-producing Enterobacteriaceae (CPE).

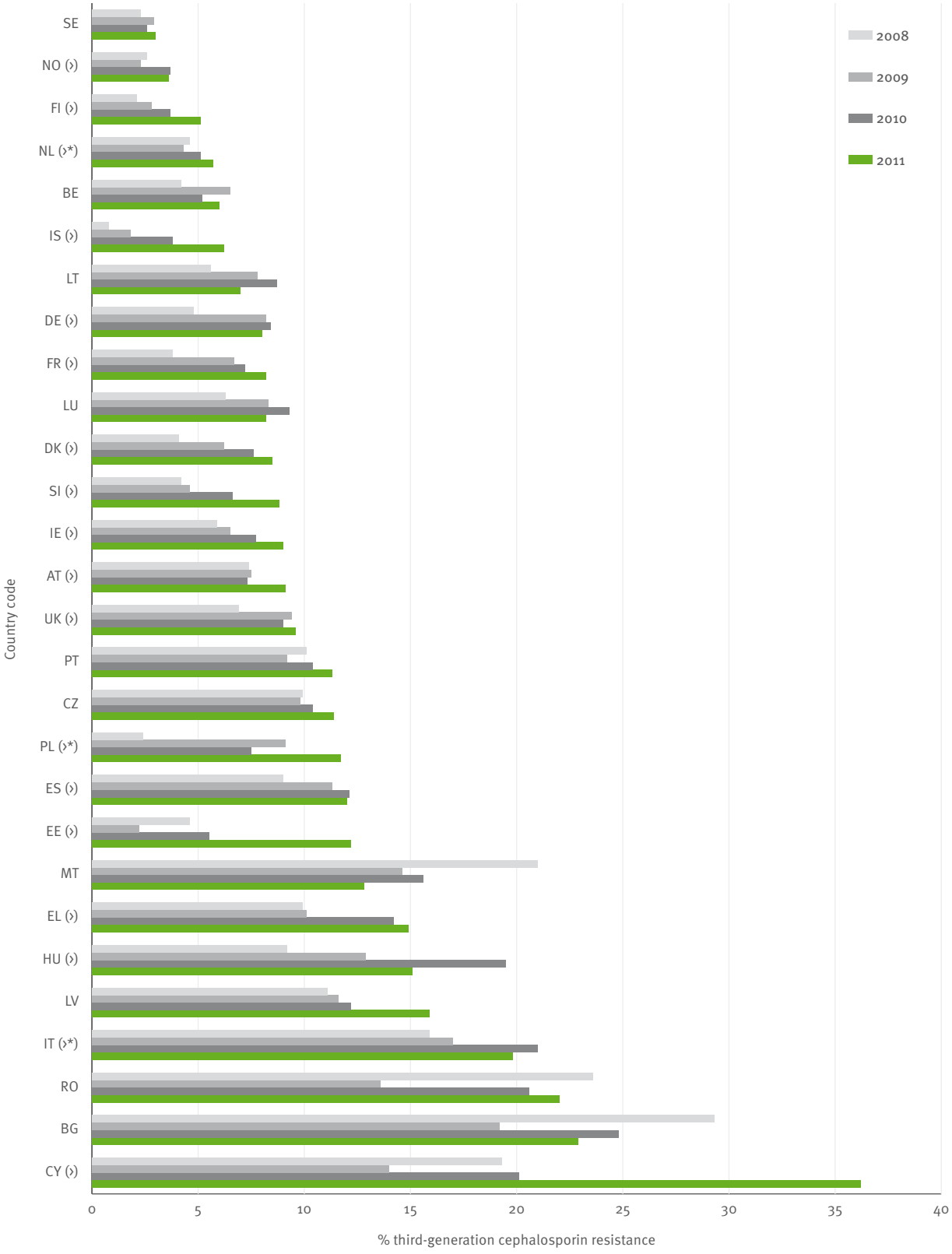
Prudent antimicrobial use and comprehensive infection control measures should be the cornerstones of interventions aiming to prevent selection and transmission of resistant bacteria, including *E. coli*. A recent risk assessment on the spread of CPE published by ECDC in 2011 emphasises that the use of standard precautions, especially adherence to hand hygiene policies, is fundamental to prevent transmission of any multidrug-resistant organisms, not only CPE, in healthcare settings[23].

Figure 4.4: *Escherichia coli*: trends of invasive isolates with resistance to aminopenicillins, by country, EU/EEA countries, 2008–2011



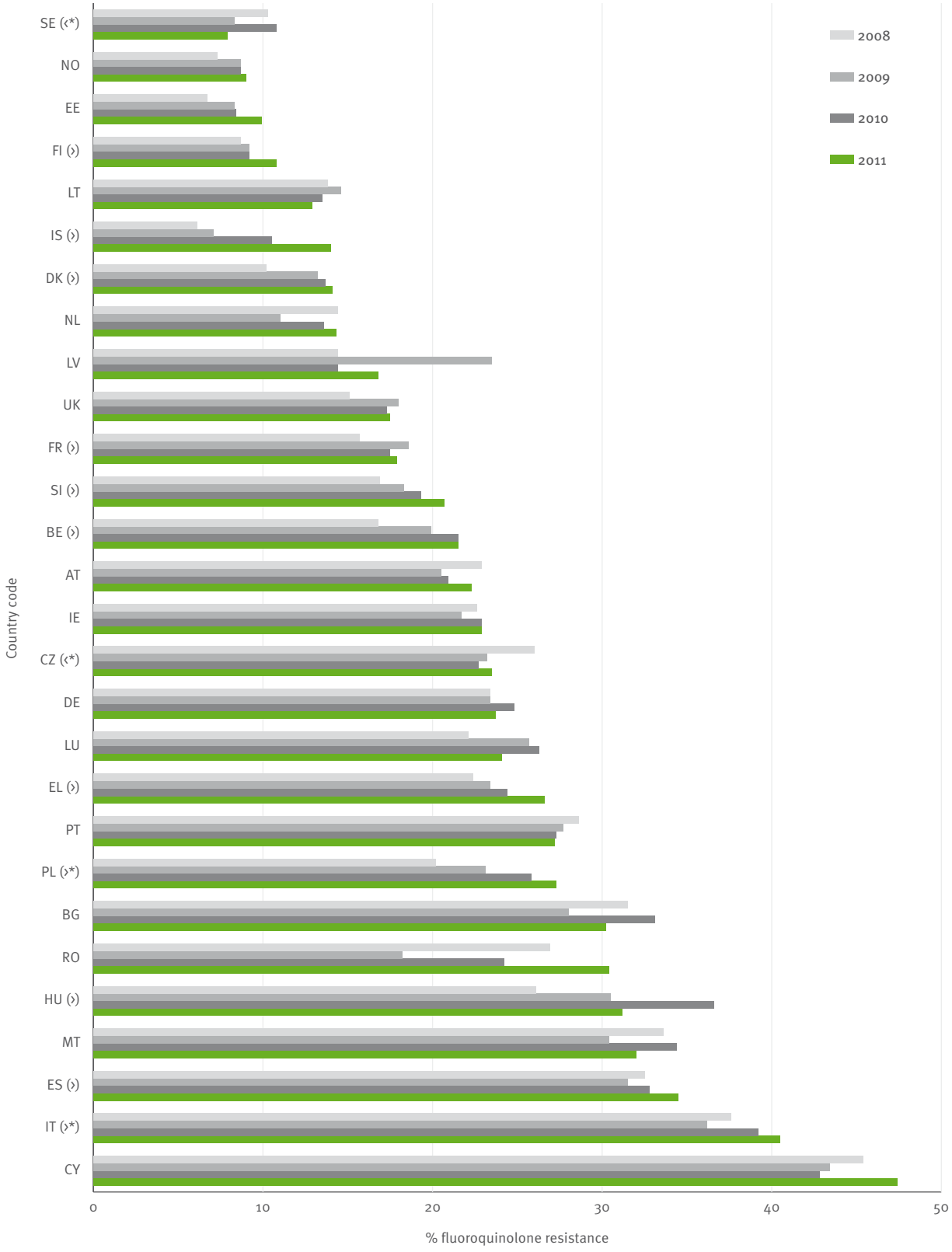
Countries not reporting data for all four years (Estonia and Slovakia) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.5: ***Escherichia coli*****: trends of invasive isolates with resistance to third-generation cephalosporins, by country, EU/EEA countries, 2008–2011**



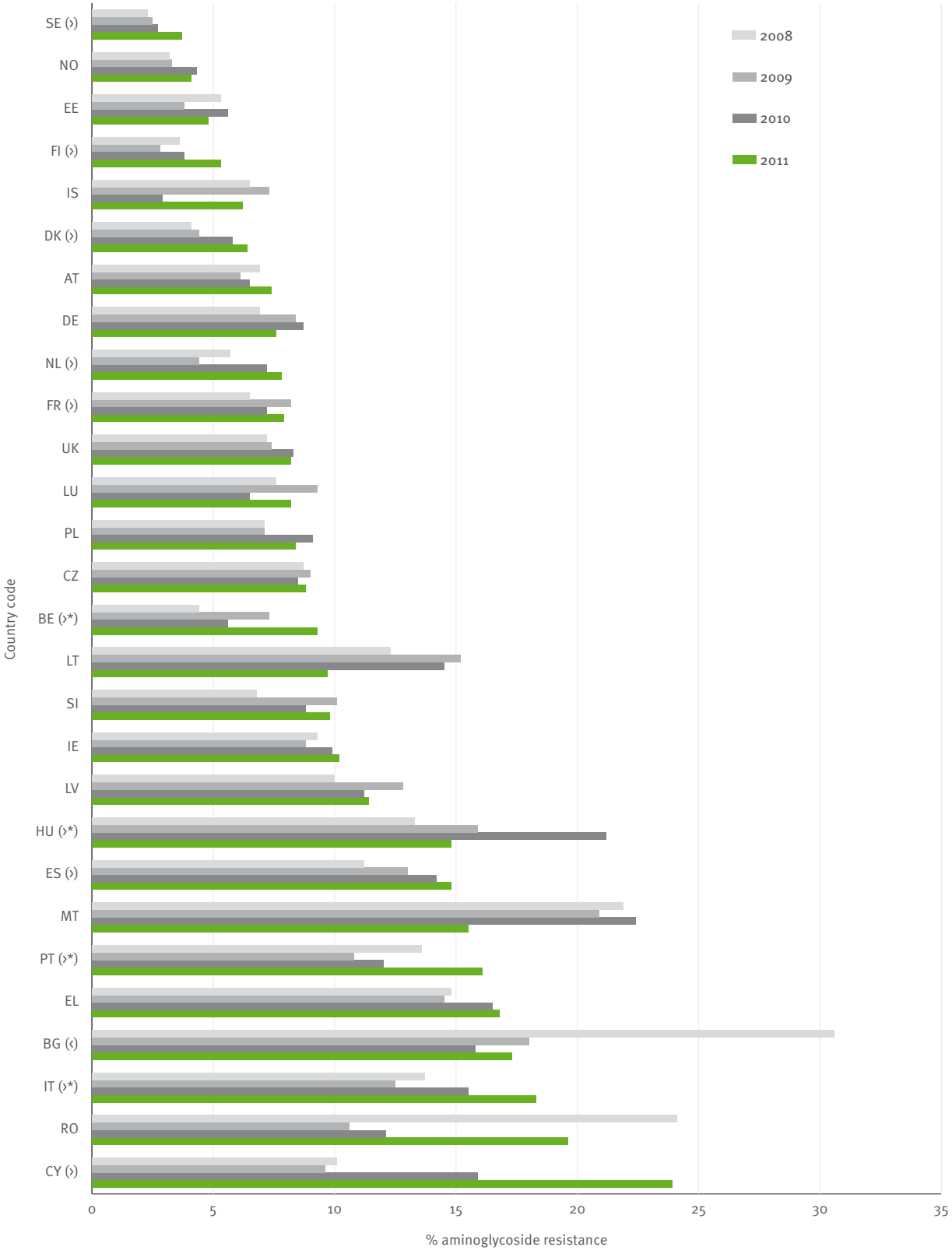
Countries not reporting data for all four years (Slovakia) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.6: *Escherichia coli*: trends of invasive isolates with resistance to fluoroquinolones, by country, EU/EEA countries, 2008–2011



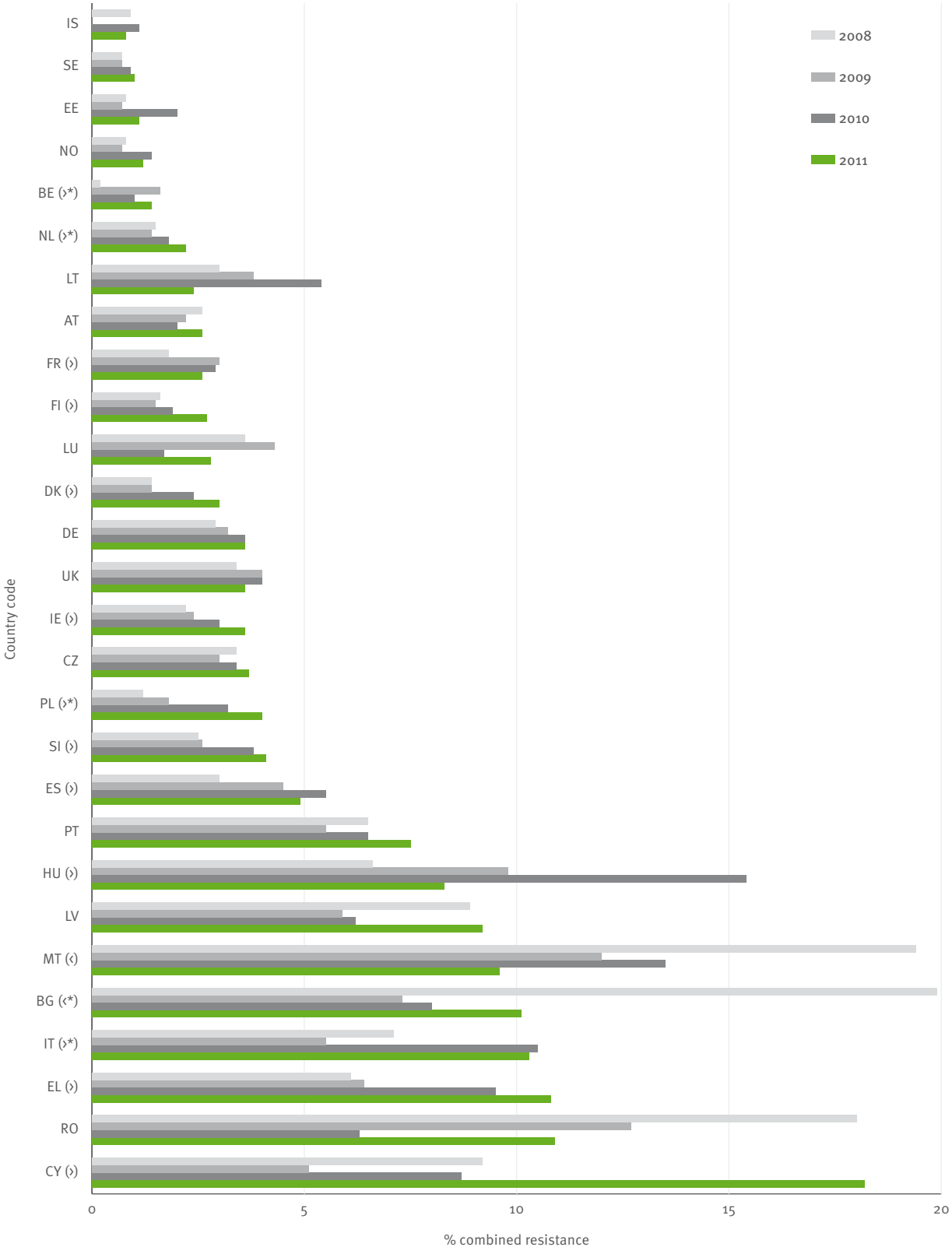
Countries not reporting data for all four years (Slovakia) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.7: ***Escherichia coli*****: trends of invasive isolates with resistance to aminoglycosides, by country, EU/EEA countries, 2008–2011**



Countries not reporting data (Slovakia) for all four years were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.8: *Escherichia coli*: trends of invasive isolates with combined resistance (resistant to fluoroquinolones, third-generation cephalosporins and aminoglycosides), by country, EU/EEA countries, 2008–2011



Countries not reporting data for all four years (Slovakia) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

4.2 *Klebsiella pneumoniae*

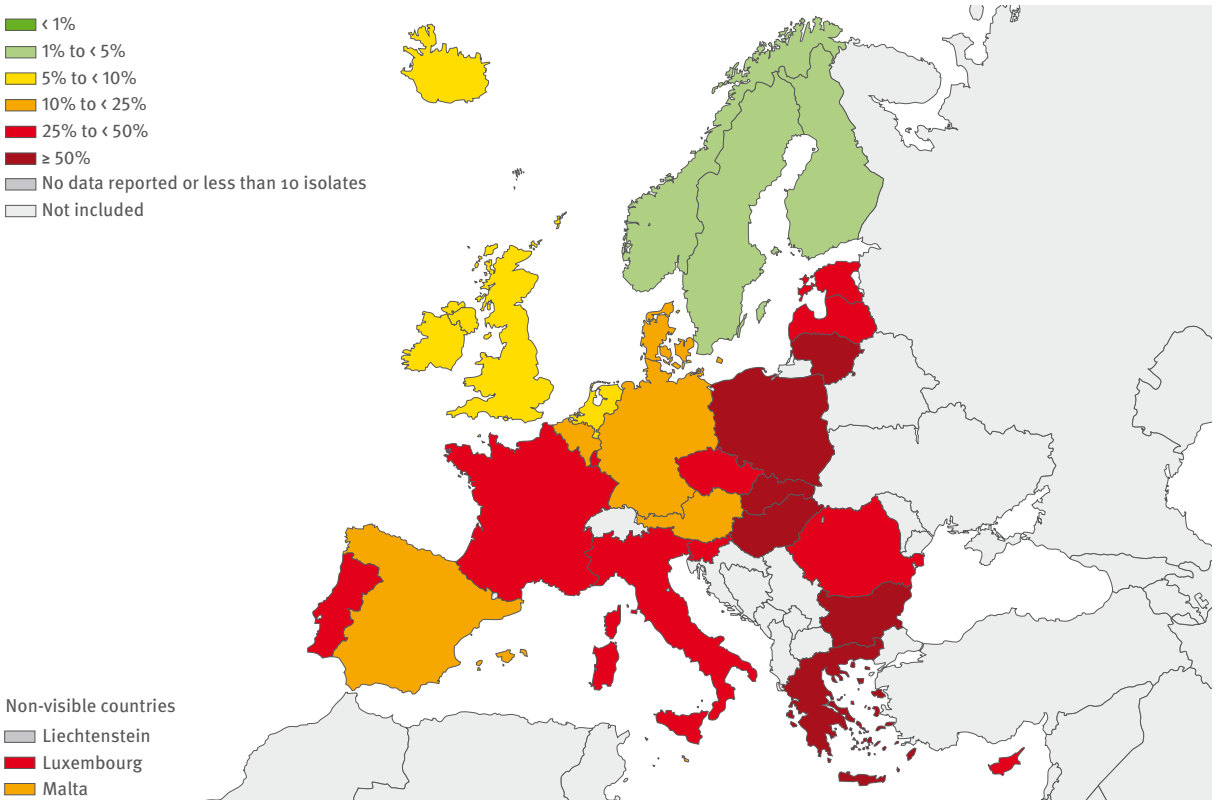
4.2.1 Clinical and epidemiological importance

Bacteria of the genus *Klebsiella* are frequent colonisers of the gastrointestinal tract in humans, but may also be found on skin, in the oropharynx and upper airways in hospitalised individuals. *Klebsiella pneumoniae* is associated with opportunistic infections in individuals with impaired immune systems, such as diabetic, alcoholic and hospitalised patients with indwelling devices. The most common sites of infection are the urinary tract and the respiratory tract. Organisms such as *K. pneumoniae* can spread rapidly, from the gastrointestinal tract of patients and via the hands of hospital personnel to colonise other patients, leading to nosocomial outbreaks. *Klebsiella pneumoniae* is the second most frequent cause of gram-negative bloodstream infections after *Escherichia coli*. The mortality rates of pneumonia caused by *K. pneumoniae* can be high even when appropriate antimicrobial treatment is given. However, this also depends on the severity of the underlying condition.

4.2.2 Resistance mechanisms

Similar to *E. coli*, *K. pneumoniae* can be resistant to multiple antimicrobials, and resistance traits are frequently acquired through plasmids. However, in contrast to *E. coli*, *K. pneumoniae* has a chromosomally encoded SHV beta-lactamase and is thus intrinsically resistant to aminopenicillins. Moreover, this organism readily acquires plasmid-mediated resistance determinants. Many novel ESBL variants were initially identified in *K. pneumoniae* and were only subsequently found in *E. coli*. Since the resistance mechanisms do not differ significantly from those described for *E. coli*, readers should refer to the *E. coli* section (4.1, above) for further details. Carbapenems have been widely used in many countries due to the increasing rate of ESBL-producing Enterobacteriaceae with a consequent impact on the emergence of resistance to these antimicrobials, especially in *K. pneumoniae*. KPC carbapenemase-producing clones of *K. pneumoniae* have been observed in the United States, Greece, Italy and Israel, and similar strains are now spreading in several European countries while plasmids encoding the VIM metallo-carbapenemase are frequent in *K. pneumoniae* in Greece. A new type of plasmidic carbapenemase, the New Delhi metallo-beta-lactamase 1 (NDM-1), has been observed in patients returning from the Indian subcontinent. The bla_{OXA-48} gene codes for an oxacillinase (OXA-48) that causes resistance to penicillin and reduces susceptibility to carbapenems, but not to expanded-spectrum cephalosporins. The level of resistance is often low and such strains are thus frequently missed in laboratories using automated AST systems. A combination of OXA-48-like enzymes with ESBLs such as CTX-M15 can occur in *Klebsiella* spp. and can result in a highly drug-resistant phenotype. Single clones with such combinations have caused hospital outbreaks in several European countries.

Figure 4.9: *Klebsiella pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins, by country, EU/EEA countries, 2011



4.2.3 Results

Third-generation cephalosporins

- For 2011, 29 countries reported 15 052 *K. pneumoniae* isolates of which 4 538 (30.1%) were resistant to third-generation cephalosporins. The number of isolates with relevant AST information reported by the countries ranged from 25 to 1 665.
- The percentages of isolates reported as resistant ranged from 2.3% (Sweden) to 81.0% (Bulgaria). Three countries reported resistance percentages below 5%, four countries reported 5–10%, six countries reported 10–25%, 10 countries reported 25–50%, and six countries reported above 50% (Figure 4.9, Table 4.4).
- Trends for the period 2008–2011 were calculated for 25 countries. Significantly increasing trends were observed for 10 countries. For Italy, the trend did not remain significant when considering only data from laboratories reporting consistently for all four years (Figure 4.14).
- None of the reporting countries had significantly decreasing trends of resistance to third-generation cephalosporins (Figure 4.14).

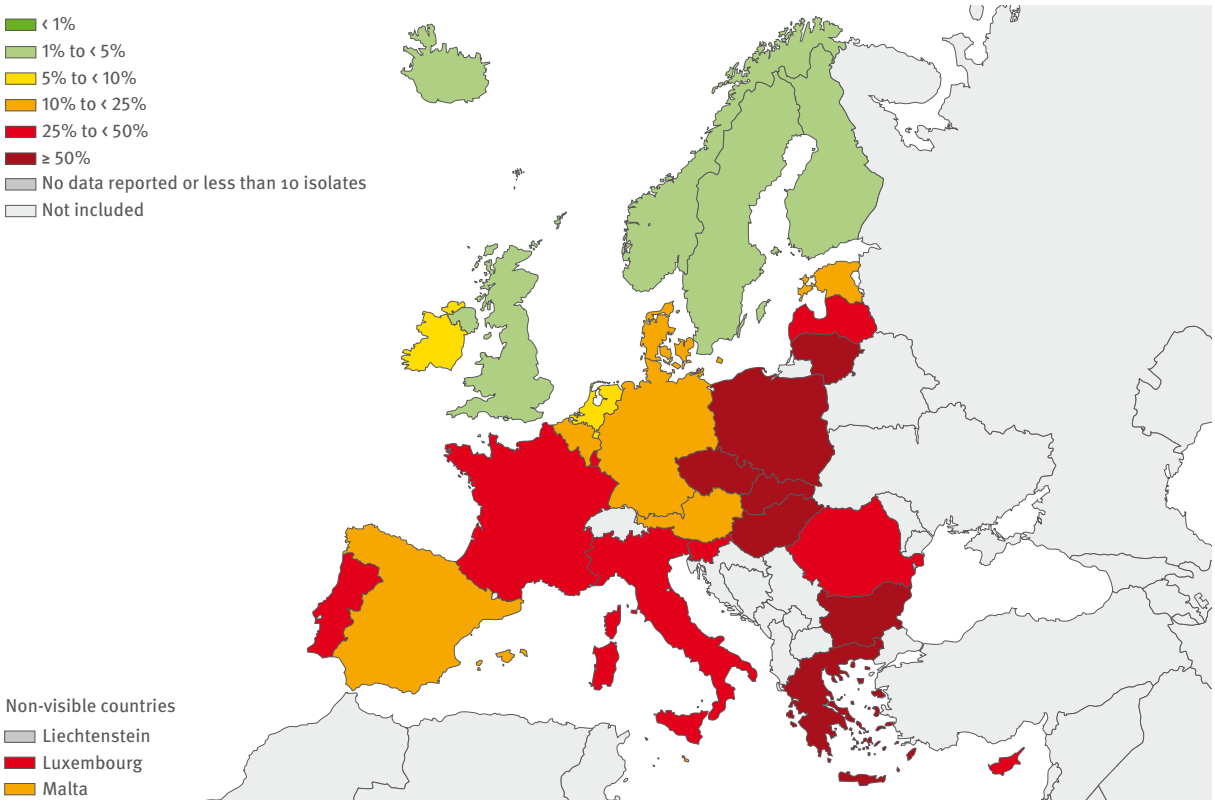
Extended-spectrum beta-lactamase (ESBL)

- Nineteen countries were included in the calculation of ESBL percentages for *K. pneumoniae*. Data were only included from laboratories reporting ESBL test results for all isolates identified as resistant to third-generation cephalosporins, and only from countries with at least 10 of such isolates.
- The percentage of *K. pneumoniae* isolates found to be resistant to third-generation cephalosporins and ascertained by the participating laboratories as ESBL producers, ranged from 65.2% to 100%. The percentages of isolates ascertained as ESBL producers were reported by 19 countries (Table 4.5).

Fluoroquinolones

- For 2011, 29 countries reported 15 329 isolates, of which 4 668 (30.5%) were resistant to fluoroquinolones. The number of isolates with relevant AST information reported per country ranged from 10 to 1 683 (Table 4.4).
- The percentage of isolates found to be resistant ranged from 1.9% (Sweden) to 72.2% (Greece). Five countries reported resistance percentages below 5%, two countries reported 5-10, seven countries reported 10–25%, eight countries reported 25–50%, and seven countries reported above 50% (Figure 4.10, Table 4.4).
- Trends for the period 2008–2011 were calculated for 25 countries. Significantly increasing trends were observed for 10 countries. For Luxembourg, the trend was not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.15).

Figure 4.10: *Klebsiella pneumoniae*: percentage (%) of invasive isolates with resistance to fluoroquinolones, by country, EU/EEA countries, 2011



- Significantly decreasing trends were observed for two countries (Denmark and Sweden) (Figure 4.15).

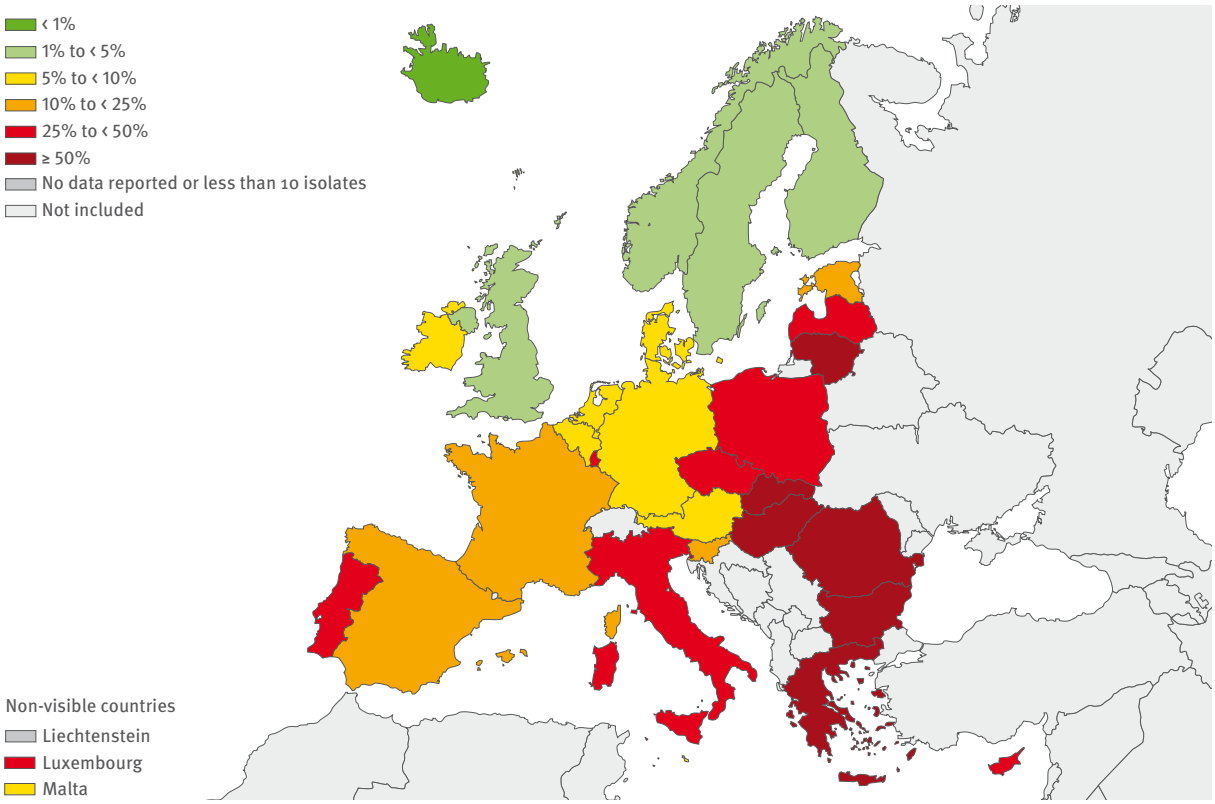
Aminoglycosides

- For 2011, 29 countries reported 15367 isolates, of which 4020 (26.2%) were resistant to aminoglycosides. The number of isolates with relevant AST information reported per country ranged from 10 to 1688.
- The percentages of resistant isolates reported by the countries ranged from zero (Iceland) to 71.7% (Bulgaria). Five countries reported resistant percentages below 5%, seven countries reported 5–10%, four countries reported 10–25%, eight countries reported 25–50%, and five countries reported above 50% (Figure 4.11, Table 4.4).
- Trends for the period 2008–2011 were calculated for 25 countries. Significantly increasing trends were observed for six countries (Greece, Hungary, Italy, France, Malta and Portugal). For Italy, the trend was not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.16).
- None of the reporting countries had significantly decreasing trends of aminoglycoside resistance.

Carbapenems

- For 2011, 28 countries reported 14594 isolates, of which 1323 (9.1%) were resistant to carbapenems. The number of isolates with relevant AST information reported by the countries ranged from 10 to 1640. Fifteen countries reported one or more resistant isolate(s) in 2011. The majority of the resistant isolates (1115 isolates; 84.3%) were reported by Greece, followed by Italy (164 isolates; 26.7%) and Cyprus (13 isolates; 15.7%).
- The percentage of isolates resistant to carbapenems reported by the countries ranged from zero (13 countries) to 68.2% (Greece). Twenty-three countries reported resistance percentages below 1%, two countries reported 1–5%, one country reported 10–25%, and two countries reported above 25% (Figure 4.12 and Table 4.4).
- Trends for the period 2008–2011 were calculated for 22 countries (Figure 4.17). Significantly increasing trends were observed for three countries (Greece, Hungary and Italy).
- Significantly decreasing trends were only observed for Norway. This trend was not significant when including only data from laboratories reporting consistently throughout the period.

Figure 4.11: *Klebsiella pneumoniae*: percentage (%) of invasive isolates with resistance to aminoglycosides, by country, EU/EEA countries, 2011



Combined resistance

- For 2011, 29 countries reported 14 532 isolates tested for susceptibility to third-generation cephalosporins, fluoroquinolones and aminoglycosides. The number of isolates with relevant AST information reported per country ranged from 10 to 1 647.
- The percentages of isolates with combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides reported by the countries ranged from zero (Iceland) to 64.1% (Greece). Three countries reported resistance percentages below 1%, eight countries reported 1–5%, two countries reported 5–10%, four countries reported 10–25%, ten countries reported 25–50%, and two countries reported above 50% (Figure 4.13, Table 4.4).
- Trends for the period 2008–2011 were calculated for 25 countries. Significantly increasing trends of combined resistance were observed for 10 countries (Figure 4.18).
- A significantly decreasing trend was only observed for the United Kingdom. This trend was not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.18).
- More detailed information on the most frequent resistance phenotypes in *K. pneumoniae* is presented in Table 4.6.

4.2.4 Discussion and conclusion

Antimicrobial resistance in *K. pneumoniae* is a public health concern of increasing importance in Europe. Resistance to third-generation cephalosporins increased significantly in several countries during the period 2008–2011. Combined resistance is common and increasing in several European countries, with 22.3% of the isolates in 2011 resistant to at least three antimicrobial classes.

Similar to reports for *E. coli*, ESBL production among *K. pneumoniae* with resistance to third-generation cephalosporins was very common. Besides the beta-lactams, ESBL producers are also commonly resistant to other antimicrobial classes, complicating the treatment of serious infections caused by these bacteria.

Further diminishing the available options for antimicrobial treatment is the increasing percentage of carbapenem-resistant *K. pneumoniae* in some European countries. This situation is of particular concern as the carbapenems are among the few effective antimicrobials available for the treatment of infections caused by multidrug-resistant *K. pneumoniae*.

Although information on carbapenemase production is very limited in EARS-Net, data from scientific publications and enhanced surveillance established by some

Table 4.4: *Klebsiella pneumoniae*: number and percentage (%) of invasive isolates with resistance to third-generation cephalosporins, fluoroquinolones, aminoglycosides, carbapenems and combined resistance*, including 95% confidence intervals (95%CI), by country, EU/EEA countries, 2011

Country	Third-gen. cephalosporins		Fluoroquinolones		Aminoglycosides		Carbapenems		Combined resistance	
	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)
Austria	795	13.3 (11-16)	797	16.6 (14-19)	790	7.2 (6-9)	610	0.2 (0-1)	785	4.1 (3-6)
Belgium	668	13.6 (11-16)	663	14.9 (12-18)	608	8.1 (6-11)	646	0.3 (0-1)	587	4.9 (3-7)
Bulgaria	121	81.0 (73-88)	121	51.2 (42-60)	120	71.7 (63-80)	116	0.0 (0-3)	120	45.8 (37-55)
Cyprus	83	41.0 (30-52)	83	36.1 (26-47)	83	27.7 (18-39)	83	15.7 (9-25)	83	25.3 (16-36)
Czech Republic	1 287	48.3 (45-51)	1 287	52.8 (50-56)	1 283	44.7 (42-48)	1 193	0.1 (0-0)	1 283	36.0 (33-39)
Denmark	637	11.1 (9-14)	888	11.6 (10-14)	908	5.8 (4-8)	589	0.0 (0-1)	633	4.9 (3-7)
Estonia	43	39.5 (25-56)	91	22.0 (14-32)	90	12.2 (6-21)	73	0.0 (0-5)	42	19.0 (9-34)
Finland	319	3.4 (2-6)	319	3.8 (2-6)	319	1.9 (1-4)	318	0.0 (0-1)	319	1.9 (1-4)
France	1 654	25.3 (23-28)	1 683	28.0 (26-30)	1 688	23.6 (22-26)	1 640	0.0 (0-0)	1 647	19.5 (18-21)
Germany	519	12.5 (10-16)	519	14.1 (11-17)	518	8.9 (7-12)	512	0.0 (0-1)	518	6.9 (5-9)
Greece	1 665	75.8 (74-78)	1 635	72.2 (70-74)	1 649	69.0 (67-71)	1 636	68.2 (66-70)	1 630	64.1 (62-66)
Hungary	431	53.1 (48-58)	420	51.0 (46-56)	430	53.0 (48-58)	413	1.9 (1-4)	417	46.0 (41-51)
Iceland	26	7.7 (1-25)	24	4.2 (0-21)	26	0.0 (0-13)	0	.	24	0.0 (0-14)
Ireland	304	7.6 (5-11)	303	8.9 (6-13)	304	7.6 (5-11)	302	0.3 (0-2)	303	3.3 (2-6)
Italy	627	45.9 (42-50)	597	45.7 (42-50)	661	34.6 (31-38)	615	26.7 (23-30)	566	32.9 (29-37)
Latvia	65	38.5 (27-51)	63	38.1 (26-51)	65	33.8 (23-47)	65	0.0 (0-6)	63	33.3 (22-46)
Lithuania	137	60.6 (52-69)	137	54.7 (46-63)	137	55.5 (47-64)	19	0.0 (0-18)	137	43.1 (35-52)
Luxembourg	48	35.4 (22-51)	48	33.3 (20-48)	48	29.2 (17-44)	48	0.0 (0-7)	48	27.1 (15-42)
Malta	52	13.5 (4-24)	52	13.5 (6-26)	52	9.6 (3-21)	52	3.8 (0-13)	52	3.8 (0-13)
Netherlands	720	8.1 (6-10)	728	7.3 (6-9)	729	8.1 (6-10)	722	0.3 (0-1)	720	4.3 (3-6)
Norway	421	2.9 (1-5)	427	3.5 (2-6)	426	2.8 (1-5)	443	0.0 (0-1)	374	0.8 (0-2)
Poland	278	59.7 (54-66)	369	57.7 (53-63)	383	47.5 (42-53)	376	0.5 (0-2)	259	37.1 (31-43)
Portugal	616	35.4 (32-39)	617	36.3 (33-40)	619	31.5 (28-35)	580	0.3 (0-1)	614	20.8 (18-24)
Romania	25	44.0 (24-65)	10	30.0 (7-65)	10	50.0 (19-81)	10	0.0 (0-31)	10	30.0 (7-65)
Slovakia	463	68.0 (64-72)	462	70.6 (66-75)	463	66.1 (62-70)	432	0.7 (0-2)	462	62.1 (58-67)
Slovenia	232	30.2 (24-37)	232	35.3 (29-42)	232	22.0 (17-28)	232	0.0 (0-2)	232	19.8 (15-26)
Spain	1 145	13.4 (11-15)	1 145	17.0 (15-19)	1 145	10.5 (9-12)	1 144	0.3 (0-1)	1 145	8.3 (7-10)
Sweden	736	2.3 (1-4)	624	1.9 (1-3)	602	1.7 (1-3)	900	0.0 (0-0)	545	0.7 (0-2)
United Kingdom	935	5.3 (4-7)	985	4.6 (3-6)	979	4.3 (3-6)	825	0.4 (0-1)	914	2.1 (1-3)

* Combined resistance defined as being resistant to third-generation cephalosporins, fluoroquinolone and aminoglycosides.

EU Member States indicate an increase in the spread of carbapenemase-producing Enterobacteriaceae (CPE) in Europe in recent years, with reports of travel-related cases, autochthonous cases and outbreaks. ECDC issued two risk assessments targeting CPE during 2011[23,24], emphasising the need for implementation of infection control measures such as active patient screening and additional hygiene precautions for the care of CPE-positive patients. In addition, countries are encouraged to develop national guidance on how to stop the spread of CPE within their country, and to actively report cases of CPE by making confirmed cases notifiable to national public health authorities. These interventions would not only target CPE but also affect the general spread of AMR.

Table 4.5: *Klebsiella pneumoniae*: number of invasive isolates resistant to third-generation cephalosporins (3GCRKP) and percentage (%) extended-spectrum beta-lactamase (ESBL)-positive among these isolates, as ascertained by participating laboratories, by country, EU/EEA countries, 2011

Country	Number of laboratories	Number of 3GCRKP	%ESBL
Austria	24	57	75.4
Bulgaria	11	53	96.2
Czech Republic	44	621	87.3
Denmark	3	10	80
Estonia	4	17	100
France	24	114	98.2
Germany	10	40	97.5
Hungary	9	91	100
Ireland	13	23	65.2
Italy	7	40	100
Latvia	5	22	90.9
Lithuania	9	83	100
Luxembourg	4	17	82.4
Netherlands	9	26	92.3
Poland	32	151	96
Portugal	14	135	93.3
Slovakia	4	176	90.3
Slovenia	8	70	98.6
Spain	24	89	86.5

Only data from laboratories consistently reporting ESBL test results for all isolates identified as resistant to third-generation cephalosporins and from countries with at least 10 of such isolates were selected for the analysis.

Table 4.6: *Klebsiella pneumoniae*: overall resistance and resistance combinations among invasive isolates tested against fluoroquinolones, third-generation cephalosporins and aminoglycosides (n=14 532), by country, EU/EEA countries, 2011

Resistance pattern	Number of isolates	% of total
Fully susceptible	9 239	63.6
Single resistance (to indicated drug classes)		
Total (all single resistance)	**987**	**6.8**
Fluoroquinolones	517	3.6
Third-generation cephalosporins	338	2.3
Aminoglycosides	132	0.9
Resistance to two classes of antimicrobial drugs		
Total (all two classes combinations)	**1 065**	**7.3**
Third-generation cephalosporins + fluoroquinolones	567	3.9
Third-generation cephalosporins + aminoglycosides	299	2.1
Fluoroquinolones + aminoglycosides	199	1.4
Resistance to three classes of antimicrobial drugs		
Third-generation cephalosporins + fluoroquinolones + aminoglycosides	3 241	22.3

Only data from isolates tested against all three antimicrobial classes were included in the analysis.

Figure 4.12: ***Klebsiella pneumoniae*: percentage (%) of invasive isolates with resistance to carbapenems, by country, EU/EEA countries, 2011**

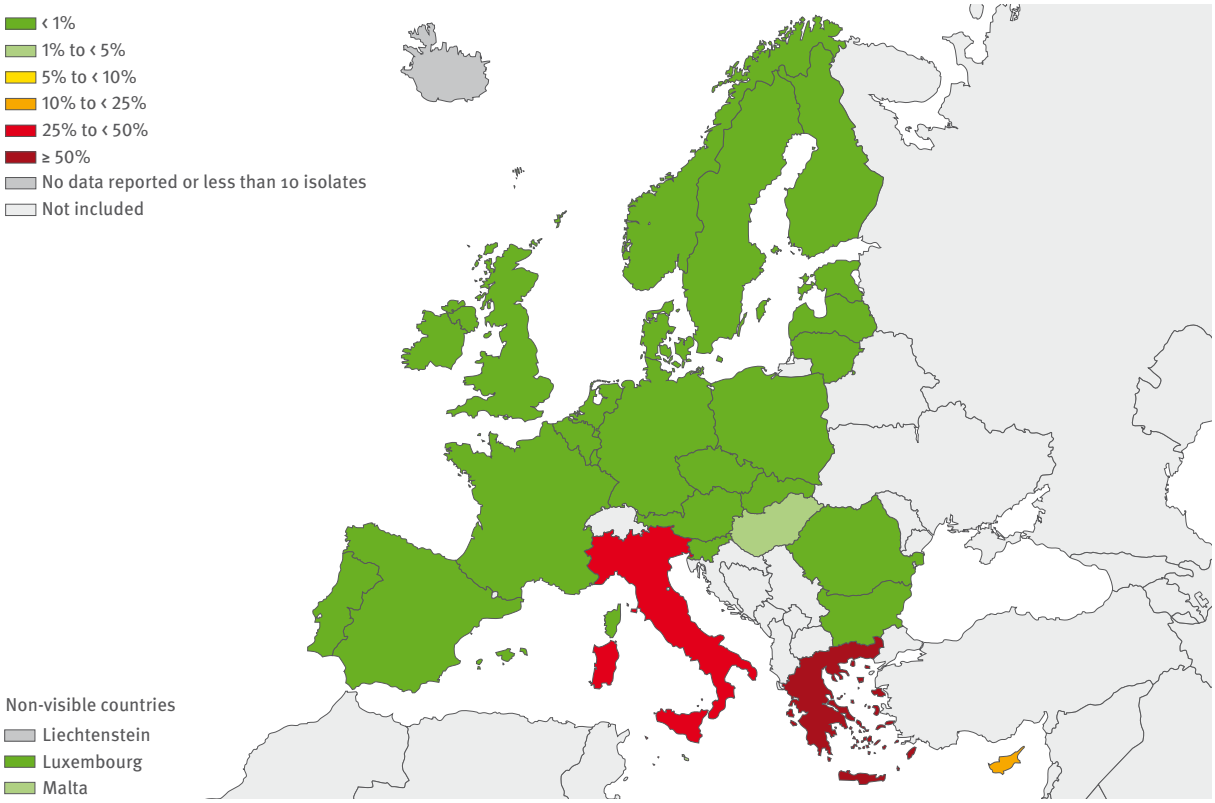


Figure 4.13: ***Klebsiella pneumoniae*: percentage (%) of invasive isolates with combined resistance (resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides), by country, EU/EEA countries, 2011**

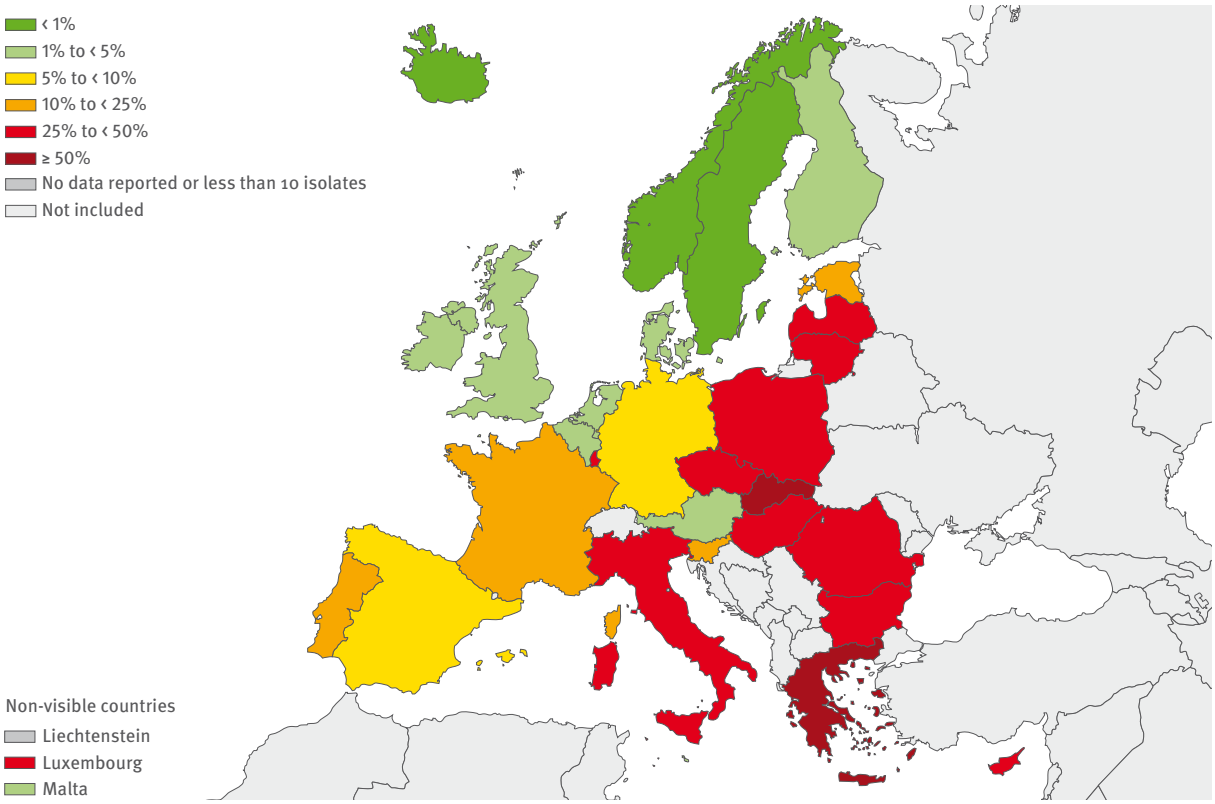
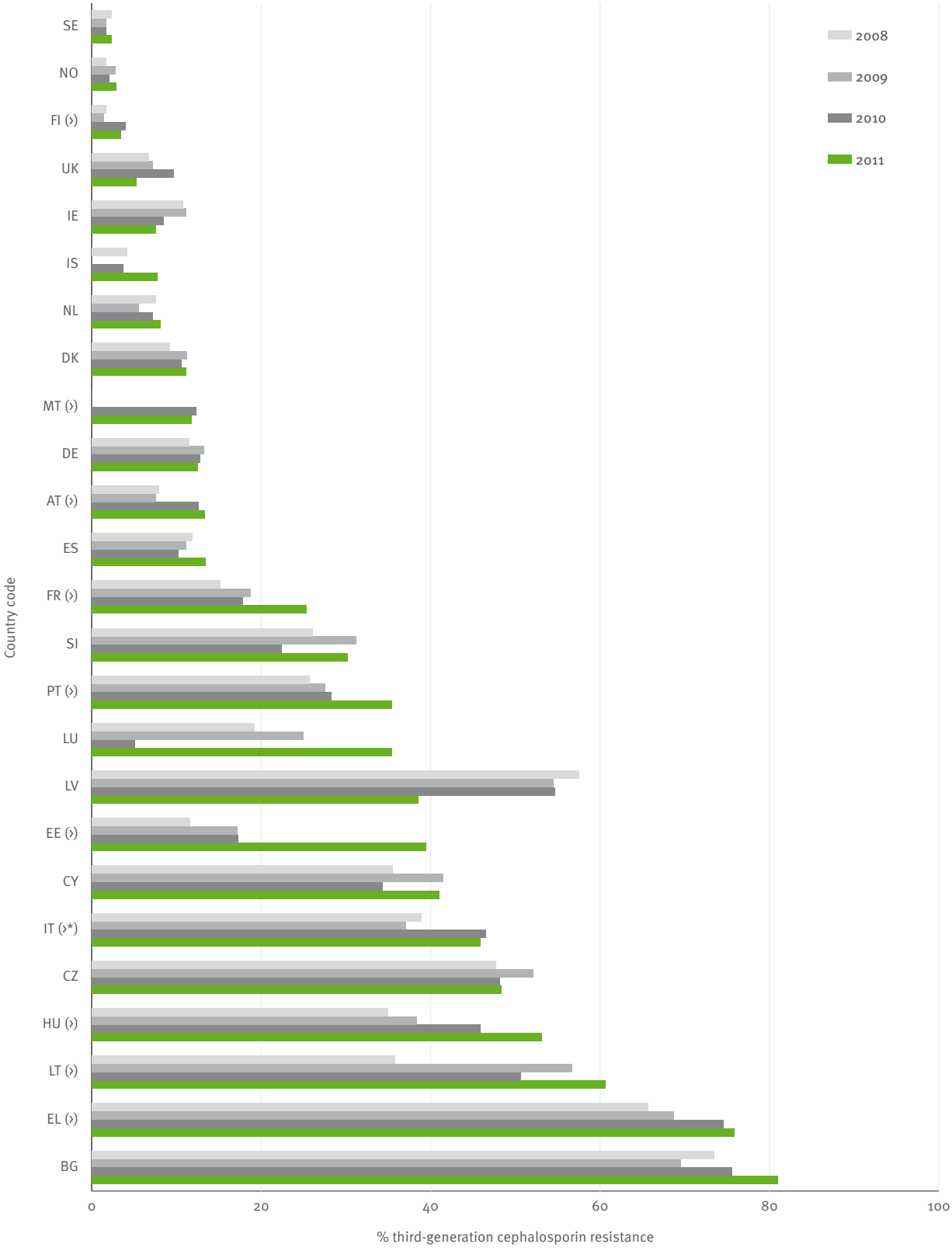
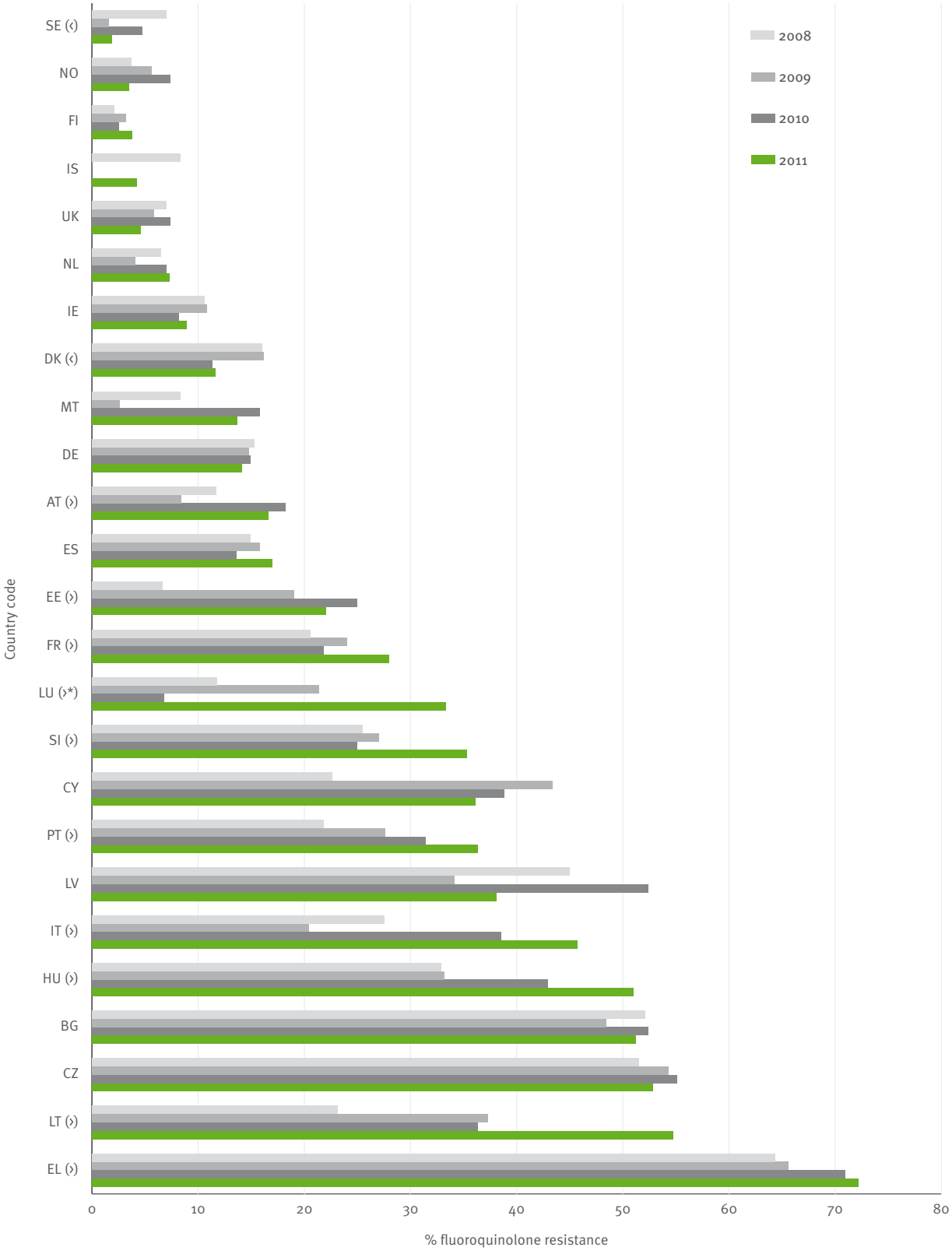


Figure 4.14: ***Klebsiella pneumoniae*: trends of invasive isolates with resistance to third-generation cephalosporins, by country, EU/EEA countries, 2008–2011**



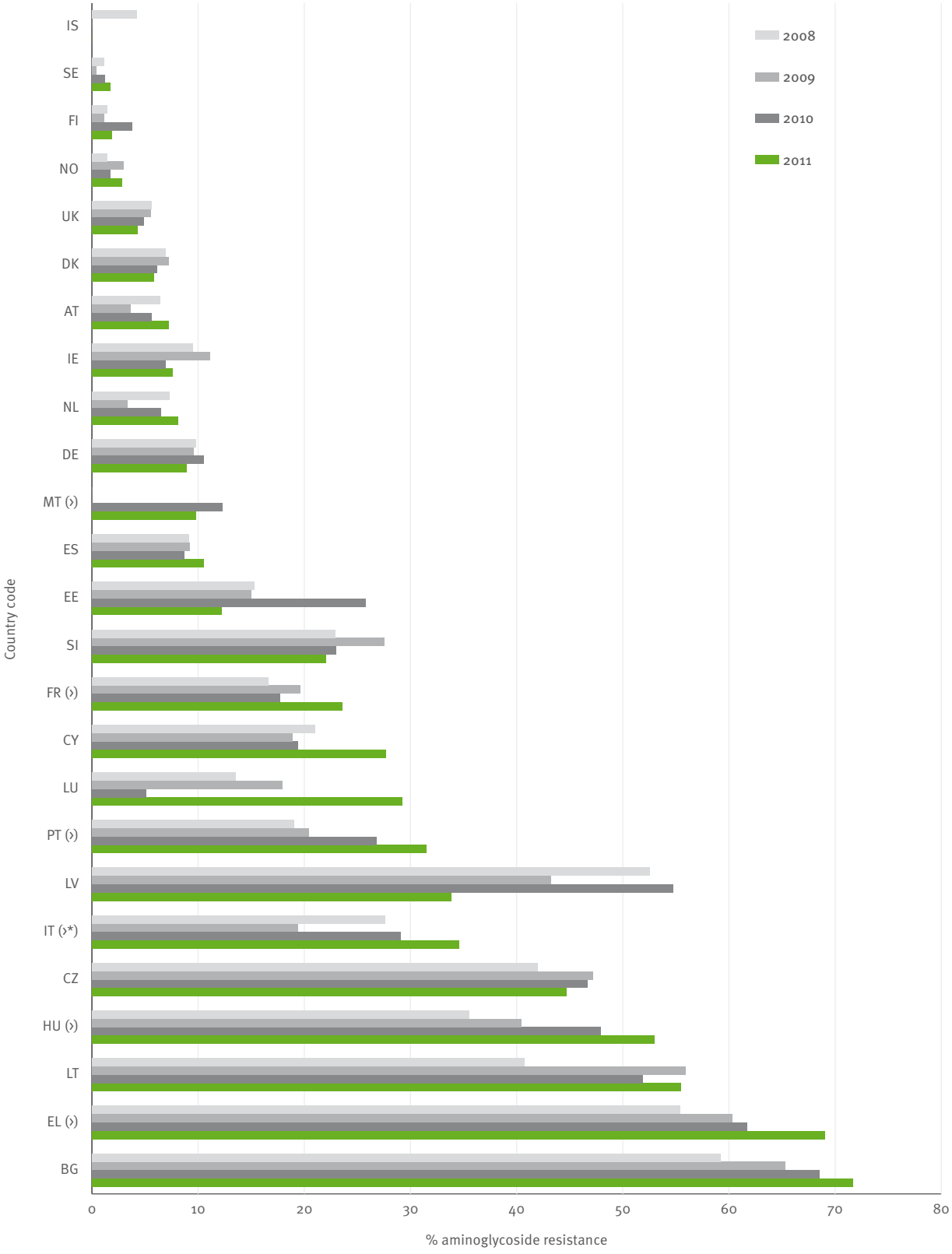
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.15: ***Klebsiella pneumoniae*****: trends of invasive isolates with resistance to fluoroquinolones, by country, EU/EEA countries, 2008–2011**



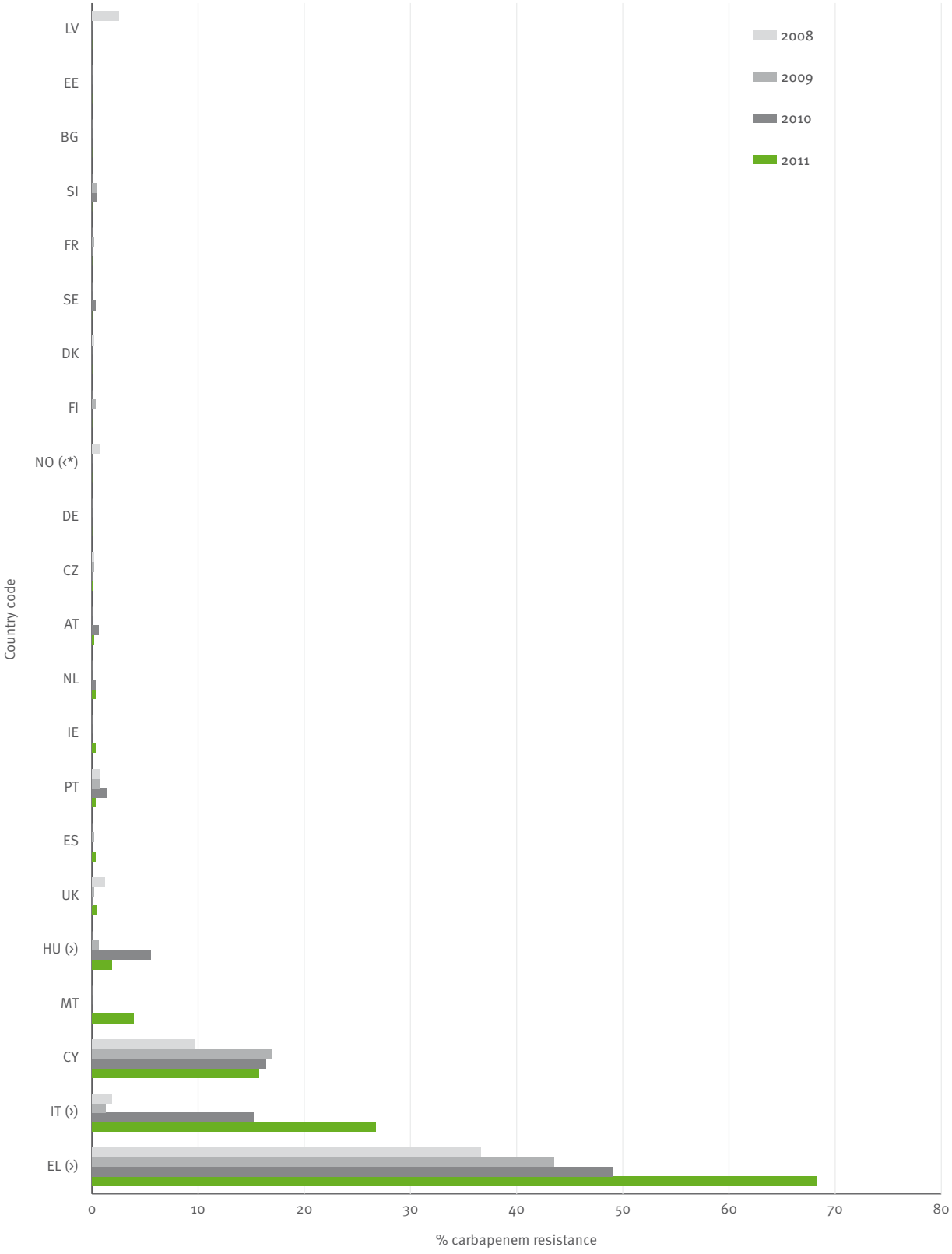
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.16: ***Klebsiella pneumoniae*: trends of invasive isolates with resistance to aminoglycosides, by country, EU/EEA countries, 2008–2011**



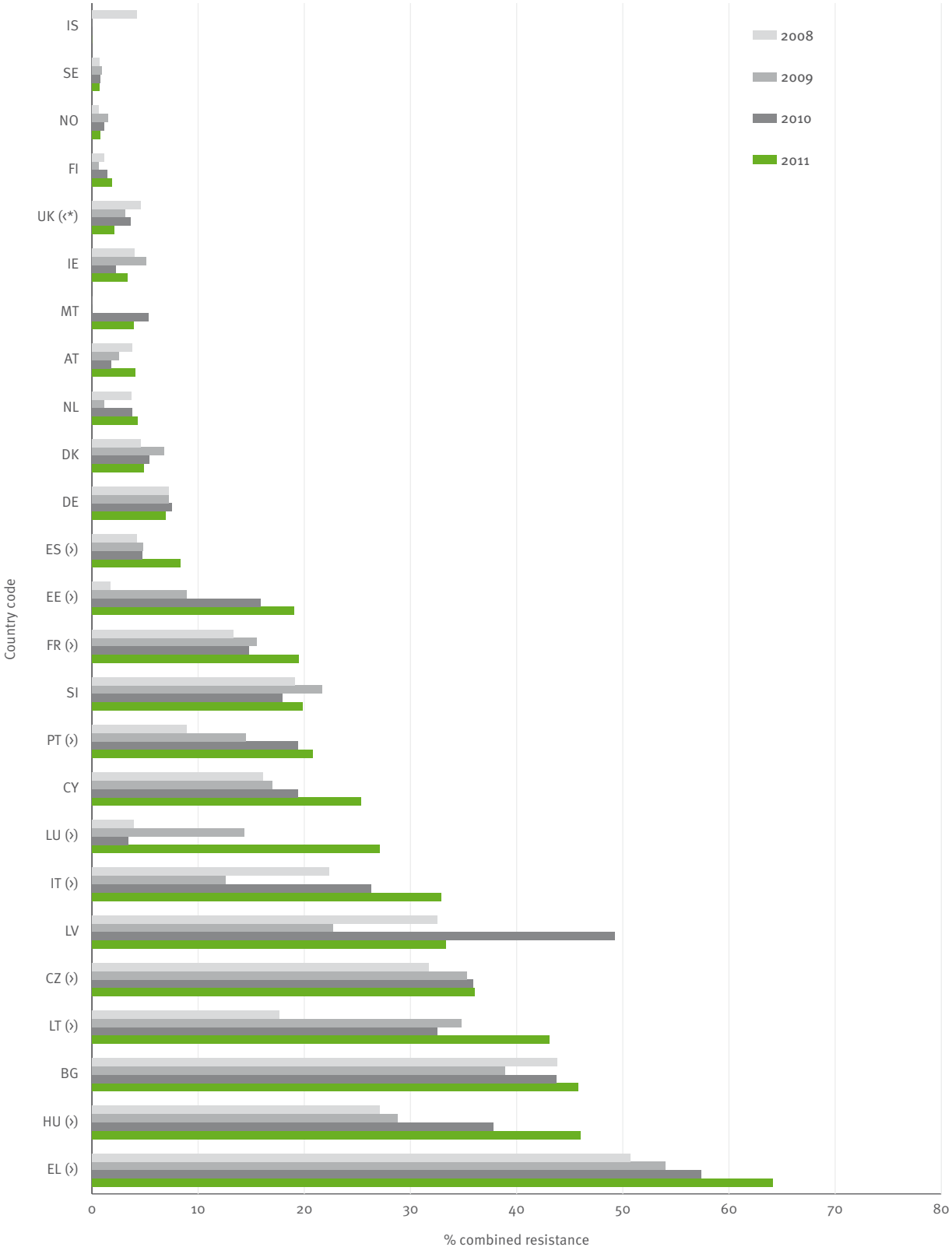
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.17: *Klebsiella pneumoniae*: trends of invasive isolates with resistance to carbapenems, by country, EU/EEA countries, 2008–2011



Countries not reporting data for all four years (Belgium, Iceland and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Lithuania, Luxembourg, Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trend, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.18: ***Klebsiella pneumoniae*: trends of invasive isolates with combined resistance (third-generation cephalosporins, fluoroquinolones and aminoglycosides), by country, EU/EEA countries, 2008–2011**



Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trend, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

4.3 *Pseudomonas aeruginosa*

4.3.1 Clinical and epidemiological importance

Pseudomonas aeruginosa is a non-fermenting gram-negative bacterium that is ubiquitous in aquatic environments in nature. It is an opportunistic pathogen for plants, animals and humans, and is a major and dreaded cause of infection in hospitalised patients with localised or systemic impairment of immune defences, being a common cause of hospital-acquired pneumonia (including ventilator-associated pneumonia), bloodstream and urinary tract infections. Because of its ubiquity, its enormous versatility and intrinsic tolerance to many detergents, disinfectants and antimicrobial compounds, it is difficult to control *P. aeruginosa* in hospitals and institutional environments. Moreover, *P. aeruginosa* is a frequent cause of skin infections such as folliculitis and otitis externa among recreational and competitive swimmers. In patients with cystic fibrosis, *P. aeruginosa* causes severe bacterial complication leading to chronic colonisation and intermittent exacerbation of the condition with, for example, bronchiolitis and acute respiratory distress syndrome. Finally, *P. aeruginosa* is commonly found in burn units, and in these locations it is almost impossible to eradicate colonising strains with classic infection control procedures.

4.3.2 Resistance mechanism

Pseudomonas aeruginosa is intrinsically resistant to the majority of antimicrobial agents due to its selective ability to exclude various molecules from penetrating its outer membrane. The antimicrobial classes that remain active include some fluoroquinolones (e.g. ciprofloxacin and levofloxacin), aminoglycosides (e.g. gentamicin, tobramycin and amikacin), some beta-lactams (piperacillin–tazobactam, ceftazidime, cefepime, imipenem, doripenem and meropenem) and colistin. Resistance of *P. aeruginosa* to these agents can be acquired through one or more of several mechanisms:

- mutational modification of antimicrobial targets such as topoisomerases or ribosomal proteins, which confer resistance to fluoroquinolones and aminoglycosides, respectively;
- mutational derepression of the chromosomally coded AmpC beta-lactamase, that can confer resistance to penicillins and cephalosporins active against *Pseudomonas* spp., and which is not inhibited by tazobactam;
- mutational loss of outer membrane proteins preventing the uptake of antimicrobial agents such as carbapenems;

Table 4.7: *Pseudomonas aeruginosa*: number and percentage (%) of invasive isolates with resistance to piperacillin(±tazobactam), ceftazidime fluoroquinolones, aminoglycosides, carbapenems and combined resistance*, including 95% confidence intervals, by country, EU/EEA countries, 2011

Country	Piperacillin± tazobactam		Ceftazidime		Fluoroquinolones		Aminoglycosides		Carbapenems		Combined resistance*	
	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)	N	%R (95%CI)
Austria	528	13.6 (11-17)	498	10.6 (8-14)	511	18.6 (15-22)	535	13.3 (11-16)	538	13.6 (11-17)	537	10.6 (8-14)
Belgium	376	15.4 (12-19)	417	8.9 (6-12)	397	21.2 (17-26)	332	14.2 (11-18)	459	10.7 (8-14)	417	11.0 (8-14)
Bulgaria	43	23.3 (12-39)	39	30.8 (17-48)	47	29.8 (17-45)	48	33.3 (20-48)	48	29.2 (17-44)	48	25.0 (14-40)
Cyprus	51	19.6 (10-33)	51	23.5 (13-37)	51	13.7 (6-26)	51	15.7 (7-29)	51	43.1 (29-58)	51	19.6 (10-33)
Czech Republic	448	22.1 (18-26)	448	20.3 (17-24)	448	33.9 (30-39)	448	24.1 (20-28)	448	13.2 (10-17)	448	21.2 (18-25)
Denmark	405	5.4 (3-8)	402	5.2 (3-8)	403	6.9 (5-10)	404	2.2 (1-4)	403	5.5 (3-8)	404	3.2 (2-5)
Estonia	3	0.0 (0-71)	4	0.0 (0-60)	16	6.3 (0-30)	14	0.0 (0-23)	12	8.3 (0-38)	12	0.0 (0-26)
Finland	164	14.0 (9-20)	168	8.3 (5-14)	185	14.6 (10-21)	221	3.6 (2-7)	221	10.4 (7-15)	185	5.9 (3-10)
France	1 572	22.5 (20-25)	1 466	16.0 (14-18)	1 554	27.0 (25-29)	1 598	21.0 (19-23)	1 622	20.0 (18-22)	1 621	18.9 (17-21)
Germany	386	14.8 (11-19)	386	9.1 (6-12)	385	18.2 (14-22)	386	11.7 (9-15)	386	9.8 (7-13)	387	7.2 (5-10)
Greece	923	31.1 (28-34)	930	37.4 (34-41)	933	38.8 (36-42)	935	37.8 (35-41)	900	54.0 (51-57)	935	38.4 (35-42)
Hungary	599	10.7 (8-13)	604	11.9 (9-15)	599	20.4 (17-24)	605	17.9 (15-21)	604	21.2 (18-25)	604	12.3 (10-15)
Iceland	17	5.9 (0-29)	17	5.9 (0-29)	16	6.3 (0-30)	17	0.0 (0-20)	17	5.9 (0-29)	17	5.9 (0-29)
Ireland	172	2.9 (1-7)	181	4.4 (2-9)	179	6.1 (3-11)	181	3.9 (2-8)	180	6.1 (3-11)	181	3.3 (1-7)
Italy	233	21.9 (17-28)	303	16.2 (12-21)	318	26.1 (21-31)	279	20.4 (16-26)	316	20.6 (16-25)	313	17.3 (13-22)
Latvia	11	9.1 (0-41)	11	9.1 (0-41)	12	25.0 (5-57)	12	25.0 (5-57)	12	8.3 (0-38)	12	8.3 (0-38)
Lithuania	30	13.3 (4-31)	29	20.7 (8-40)	30	16.7 (6-35)	30	13.3 (4-31)	30	20.0 (8-39)	30	10.0 (2-27)
Luxembourg	32	15.6 (5-33)	32	9.4 (2-25)	32	18.8 (7-36)	32	15.6 (5-33)	32	15.6 (5-33)	32	15.6 (5-33)
Malta	42	23.8 (11-38)	42	11.9 (4-26)	42	19.0 (9-35)	42	33.3 (18-48)	42	23.8 (11-38)	42	23.5 (11-38)
Netherlands	391	6.4 (4-9)	434	4.6 (3-7)	434	7.1 (5-10)	434	4.6 (3-7)	431	3.5 (2-6)	434	3.0 (2-5)
Norway	142	4.9 (2-10)	146	3.4 (1-8)	147	5.4 (2-10)	147	0.0 (0-2)	148	4.1 (2-9)	148	1.4 (0-5)
Poland	191	31.4 (25-39)	142	23.2 (17-31)	194	30.4 (24-37)	191	33.5 (27-41)	184	24.5 (18-31)	194	25.8 (20-33)
Portugal	522	19.0 (16-23)	526	15.2 (12-19)	516	25.6 (22-30)	526	15.2 (12-19)	505	19.8 (16-24)	525	16.2 (13-20)
Romania	6	66.7 (22-96)	8	62.5 (24-91)	8	75.0 (35-97)	9	66.7 (30-93)	9	66.7 (30-93)	9	66.7 (30-93)
Slovakia	264	41.3 (35-47)	248	25.0 (20-31)	264	58.7 (53-65)	264	50.8 (45-57)	249	30.5 (25-37)	265	39.6 (34-46)
Slovenia	118	12.7 (7-20)	118	7.6 (4-14)	118	9.3 (5-16)	118	7.6 (4-14)	118	23.7 (16-32)	118	10.2 (5-17)
Spain	833	6.4 (5-8)	836	8.9 (7-11)	838	24.2 (21-27)	839	18.7 (16-22)	839	16.3 (14-19)	839	12.6 (10-15)
Sweden	289	4.2 (2-7)	378	5.3 (3-8)	344	5.8 (4-9)	234	0.9 (0-3)	390	7.7 (5-11)	379	1.8 (1-4)
United Kingdom	557	4.3 (3-6)	578	4.8 (3-7)	585	6.2 (4-8)	590	3.4 (2-5)	540	5.6 (4-8)	587	2.6 (1-4)

* Combined resistance defined as being resistant to three or more antibiotic classes among piperacillin±tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems.

- mutational upregulation of efflux systems, that can confer resistance to beta-lactams, fluoroquinolones and aminoglycosides; and
- acquisition of plasmid-mediated resistance genes coding for various beta-lactamases and aminoglycoside-modifying enzymes that can confer resistance to various beta-lactams including carbapenems (e.g. metallo-beta-lactamases) and aminoglycosides, or coding for rRNA ribosomal methylases that can confer high-level resistance to all aminoglycosides.

4.3.3 Results

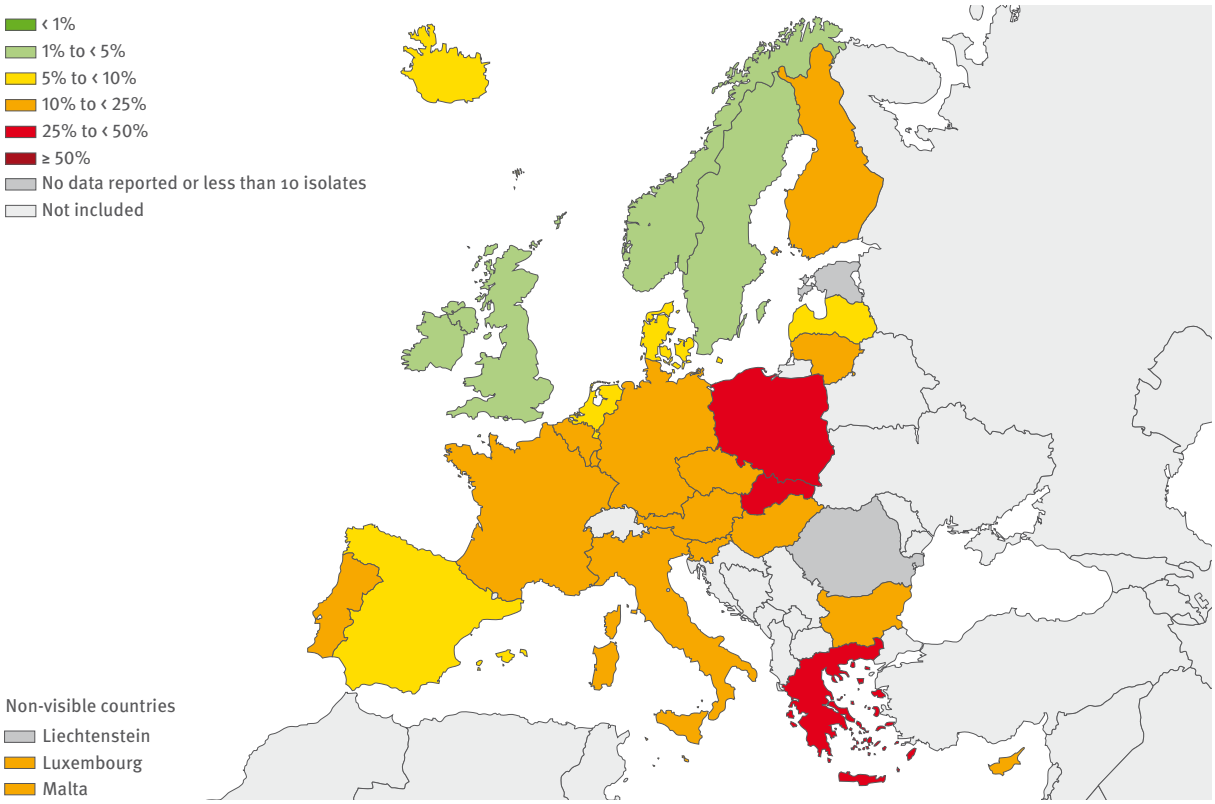
Piperacillin (± tazobactam)

- For 2011, 29 countries reported 9348 isolates, of which 1538 (16.5%) were resistant to piperacillin (±tazobactam). The number of isolates with relevant AST information reported per country ranged from 3 to 1572. Two countries (Estonia and Romania) reported fewer than 10 isolates and are thus not shown in Figure 4.19.
- The percentages of resistant isolates reported by the countries ranged from zero (Estonia) to 66.7% (Romania). Five countries reported resistance percentages lower than 5%, five countries reported 5–10%, 15 countries reported 10–25%, three countries reported 25–50%, and one country reported above 50% (Figure 4.19 and Table 4.7).
- Trends for the period 2008–2011 were calculated for 23 countries. Significantly increasing trends were observed for six countries (Austria, Denmark, Finland, France, Sweden and United Kingdom). For Finland, the trend was not significant when considering only data from laboratories reporting consistently throughout the period (Figure 4.25).
- Significantly decreasing trends were observed for three countries (Bulgaria, Hungary and Malta). For Bulgaria and Hungary, the trends were not significant when considering only data from laboratories reporting consistently throughout the period (Figure 4.25).

Ceftazidime

- For 2011, 29 countries reported 9442 isolates, of which 1338 (14.2%) were resistant to ceftazidime. The number of isolates with relevant AST information reported per country ranged from 4 to 1466. Two countries (Estonia and Romania) reported fewer than 10 isolates and are thus not included in Figure 4.20.
- The percentages of resistant isolates reported by the countries ranged from zero (Estonia) to 62.5% (Romania). Five countries reported resistance percentages lower than 5%, 10 countries reported 5–10%, 10 countries reported 10–25%, three countries reported 25–50%, and one country reported above 50% (Figure 4.20, Table 4.7).

Figure 4.19: *Pseudomonas aeruginosa*: percentage (%) of invasive isolates with resistance to piperacillin±tazobactam, by country, EU/EEA countries, 2011



- Trends for the period 2008–2011 were calculated for 23 countries. Significantly increasing trends were observed for Austria and France (Figure 4.26).
- Significantly decreasing trends were observed for the Czech Republic and Malta (Figure 4.26).

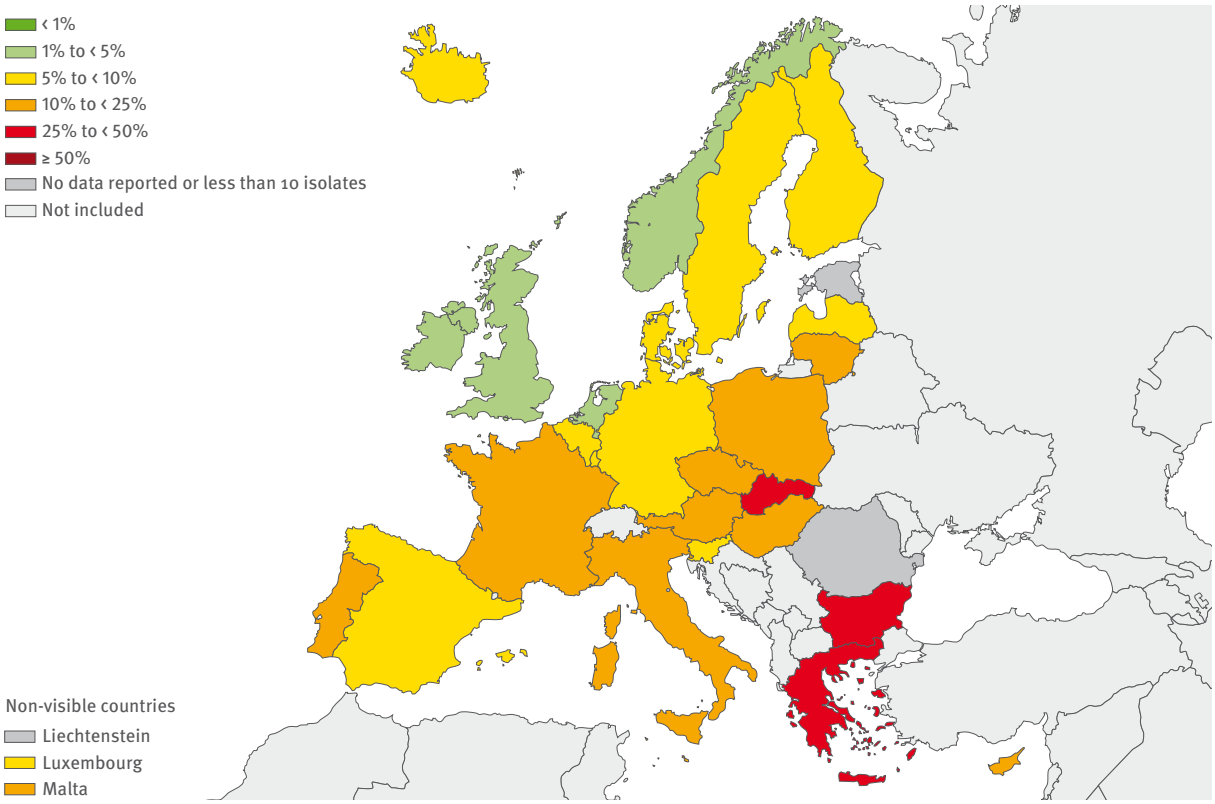
Fluoroquinolones

- For 2011, 29 countries reported 9606 isolates, of which 2159 (22.5%) were resistant to fluoroquinolones. The number of isolates with relevant AST information reported per country ranged from 8 to 1554. One country (Romania) reported fewer than 10 isolates and is thus not included in Figure 4.21.
- The percentages of resistant isolates reported by the countries ranged from 5.4% (Norway) to 75.0% (Romania). Nine countries reported resistance percentages of 5–10%, 10 countries reported 10–25%, eight countries reported 25–50%, and two countries reported above 50% (Figure 4.21, Table 4.7).
- Trends for the period 2008–2011 were calculated for 21 countries. Significantly increasing trends were observed for three countries (Austria, Denmark and France). For France, the trend was not significant when including only data from laboratories reporting consistently for all four years (Figure 4.27).
- Significantly decreasing trends were observed for seven countries (Czech Republic, Cyprus, Greece, Hungary, Ireland, Italy and Slovenia). For Hungary and Italy, the trends were not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.27).

Aminoglycosides

- For 2011, 29 countries reported 9522 isolates, of which 1690 (17.7%) were resistant to aminoglycosides. The number of isolates with relevant AST information reported per country ranged from 9 to 1598. One country (Romania) reported fewer than 10 isolates and is thus not included in Figure 4.22).
- The percentage of resistant isolates reported by the countries ranged from zero (Estonia, Iceland and Norway) to 66.7% (Romania). Four countries reported resistance percentages lower than 1%, five countries reported 1–5%, one country reported 5–10%, 12 countries reported 10–25%, five countries reported 25–50%, and two countries reported above 50% (Figure 4.22, Table 4.7).
- Trends for the period 2008–2011 were calculated for 23 countries. Significantly increasing trends were observed for three countries (Austria, France and Portugal). For France and Portugal, the trends were not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.28).

Figure 4.20: *Pseudomonas aeruginosa*: percentage (%) of invasive isolates with resistance to ceftazidine, by country, EU/EEA countries, 2011



- Significantly decreasing trends were observed for four countries (Czech Republic, Greece, Hungary, and Italy). For Italy, the trend was not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.28).

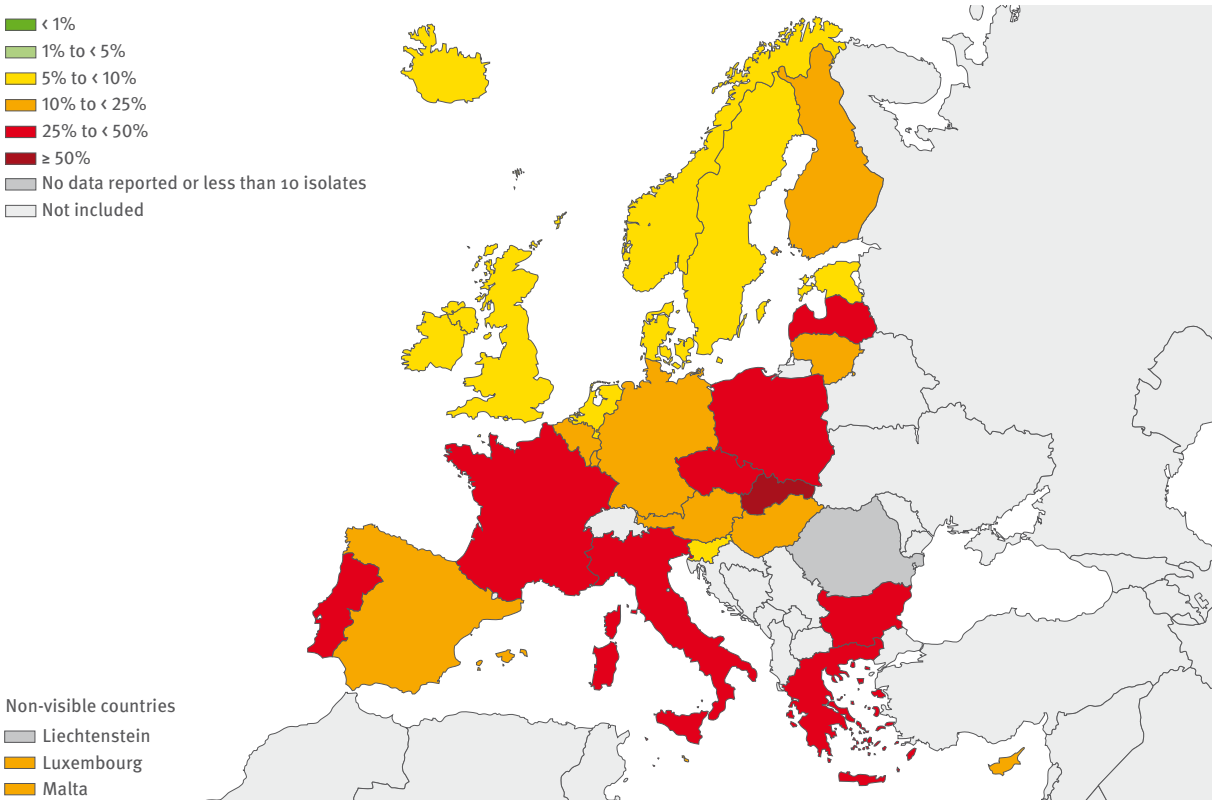
Carbapenems

- For 2011, 29 countries reported 9734 isolates, of which 1807 (18.6%) were resistant to carbapenems. The number of isolates with relevant AST information reported per country ranged from 9 to 1622. One country (Romania) reported fewer than 10 isolates and is thus not included in Figure 4.23.
- The percentages of resistant isolates reported by the countries ranged from 3.5% (the Netherlands) to 66.7% (Romania). Two countries reported resistance percentages of 1–5%, eight countries reported 5–10%, 14 countries reported 10–25%, three countries reported 25–50%, and two countries reported above 50% (Figure 4.23 and Table 4.7).
- Trends for the period 2008–2011 were calculated for 22 countries. Significantly increasing trends were observed for five countries (Austria, Cyprus, Denmark, Greece and France). For Greece, the trend was not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.29).
- Significantly decreasing trends were observed for four countries (Hungary, Italy, the Czech Republic, and the Netherlands). For Hungary, Italy and the Netherlands, the trends were not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.29).

Combined resistance (piperacillin±tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems)

- For 2011, 29 countries reported 9774 isolates tested for susceptibility to at least three antimicrobial classes among piperacillin±tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems. The number of isolates with relevant AST information reported per country ranged from 9 to 1621 (Table 4.7).
- In 2011, 34.7% of the isolates were resistant to one or more of the five considered antimicrobial classes, while 15.3% were resistant to three or more. The most common pattern was resistance to all five antimicrobial classes (4.6%) (Table 4.8).
- The percentages of isolates with combined resistance, i.e. resistant (R) to at least three of the five considered antimicrobial classes, were below 1% in one country, 1–5% in six countries, 5–10% in four countries, 10–25% in 13 countries, 25–50% in four countries and above 50% in one country (Figure 4.24, Table 4.7).
- Trends for the period 2008–2011 were calculated for 22 countries. Significantly increasing trends of combined resistance were observed for three countries (Austria, Denmark and France). For France, the trend

Figure 4.21: *Pseudomonas aeruginosa*: percentage (%) of invasive isolates with resistance to fluoroquinolones, by country, EU/EEA countries, 2011



was not significant when including only data from laboratories consistently reporting for all four years (Figure 4.30).

- Significantly decreasing trends of combined resistance were observed for four countries (the Czech Republic, Greece, Hungary, and Italy). For Italy, the trend was not significant when including only data from laboratories consistently reporting for all four years (Figure 4.30).

4.3.4 Discussion and conclusions

In 2011, high percentages of resistance in *P. aeruginosa* isolates were reported, especially by countries in southern and eastern Europe. Combined resistance was common; 15.3% of the isolates were resistant to at least three antimicrobial classes and 4.6% of the isolates were resistant to all five antimicrobial classes under surveillance. *Pseudomonas aeruginosa* carries intrinsic resistance to a number of antimicrobial classes and any additional acquired resistance severely limits the therapeutic options for treatment of serious infections.

Pseudomonas aeruginosa is recognised as a major cause of healthcare-associated infection, and in data reported from HAI-Net ICU surveillance, this pathogen was one of the most commonly isolated bacteria in pneumonia and bloodstream infections in European ICUs in 2009[25].

Although EARS-Net reports high percentages of resistance in *P. aeruginosa* isolates for 2011, the situation appears generally stable in Europe with few countries reporting significantly increasing or decreasing trends of resistance to the antimicrobial agents under surveillance. However, due to its ubiquitous nature and potential virulence, *P. aeruginosa* is a challenging pathogen to control in healthcare settings. Prudent antimicrobial use and high standards of infection control are essential to prevent the situation from deteriorating.

Table 4.8: *Pseudomonas aeruginosa*: overall resistance and resistance combinations among invasive isolates tested against at least three antimicrobial classes among piperacillin±tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems (n=9774), EU/EEA countries, 2011

Resistance pattern	Number of isolates	% of total
Fully susceptible (to tested antimicrobials)	6379	65.3
Single resistance (to indicated drug classes)		
Total (all single resistance types)	**1208**	**12.4**
Fluoroquinolones	430	4.4
Carbapenems	436	4.5
Aminoglycosides	162	1.7
Ceftazidime	78	0.8
Piperacillin(±tazobactam)	102	1
Resistance to two classes of antimicrobials		
Total (all two classes combinations)	**696**	**7.1**
Fluoroquinolones + aminoglycosides	211	2.2
Piperacillin (±tazobactam) + ceftazidime	199	2
Fluoroquinolones + carbapenems	103	1.1
Piperacillin (±tazobactam) +fluoroquinolones	33	0.3
Piperacillin (±tazobactam) + carbapenems	38	0.4
Piperacillin (±tazobactam) + aminoglycosides	33	0.3
Aminoglycosides +carbapenems	33	0.3
Ceftazidime + carbapenems	17	0.2
Fluoroquinolones + ceftazidime	20	0.2
Ceftazidime + aminoglycosides	9	0.1
Resistance to three classes of antimicrobials		
Total (all three classes combinations)	**520**	**5.3**
Fluoroquinolones + aminoglycosides + carbapenems	181	1.9
Piperacillin (±tazobactam) + fluoroquinolones +aminoglycosides	112	1.1
Piperacillin (±tazobactam) + ceftazidime + carbapenems	66	0.7
Piperacillin (±tazobactam) + fluoroquinolones + ceftazidime	51	0.5
Fluoroquinolones + ceftazidime + carbapenems	18	0.2
Fluoroquinolones +ceftazidime +aminoglycosides	29	0.3
Piperacillin (±tazobactam) + aminoglycosides + carbapenems	14	0.1
Piperacillin (±tazobactam) + ceftazidime +aminoglycosides	15	0.2
Ceftazidime + aminoglycosides + carbapenems	10	0.1
Piperacillin (±tazobactam) + fluoroquinolones + carbapenems	24	0.2
Resistance to four classes of antimicrobials		
Total (all four classes combinations)	**522**	**5.3**
Piperacillin (±tazobactam) + fluoroquinolones + aminoglycosides + carbapenems	146	1.5
Fluoroquinolones + ceftazidime + aminoglycosides + carbapenems	130	1.3
Piperacillin (±tazobactam) + fluoroquinolones + ceftazidime + aminoglycosides	123	1.3
Piperacillin (±tazobactam) + fluoroquinolones + ceftazidime + carbapenems	94	1
Piperacillin (±tazobactam) + ceftazidime + aminoglycosides + carbapenems	29	0.3
Resistance to five classes of antimicrobials		
Piperacillin (±tazobactam) + fluoroquinolones + ceftazidime + aminoglycosides + carbapenems	449	4.6

Figure 4.22: *Pseudomonas aeruginosa*: proportion (%) of invasive isolates with resistance to aminoglycosides, by country, EU/EEA countries, 2011

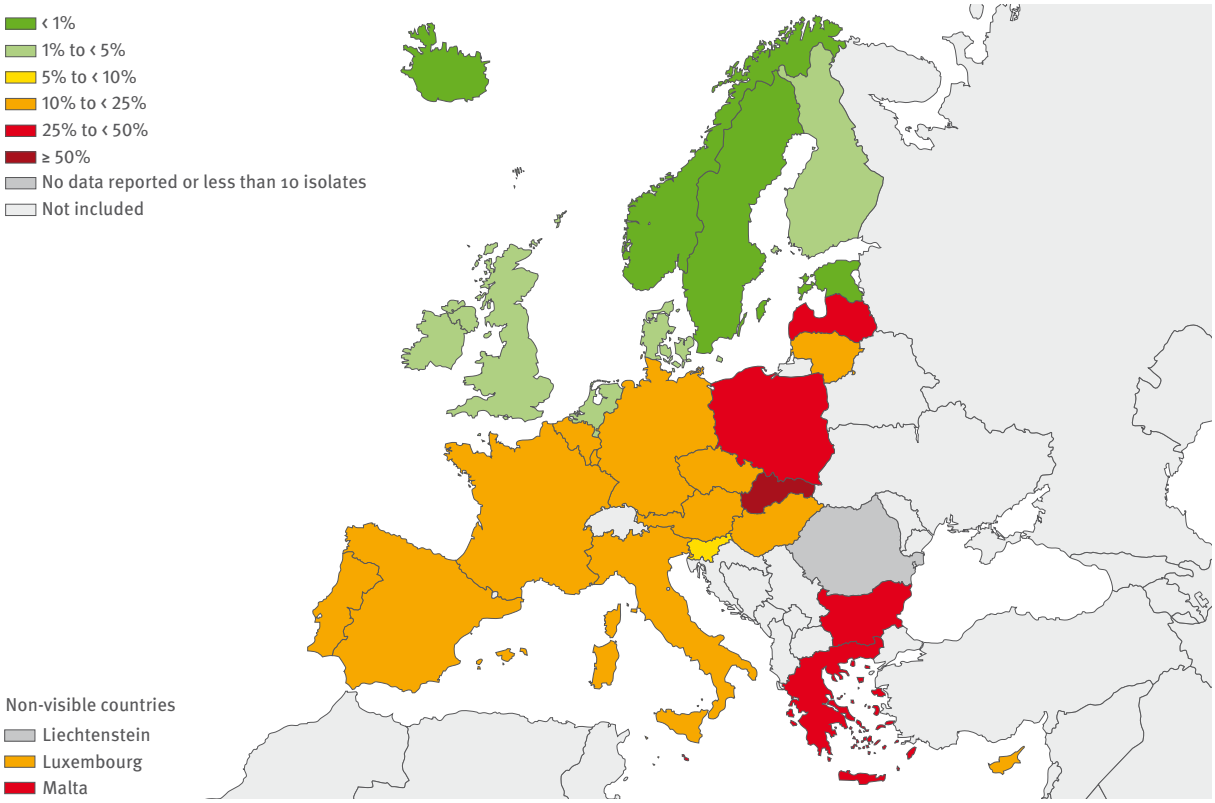


Figure 4.23: *Pseudomonas aeruginosa*: percentage (%) of invasive isolates with resistance to carbapenems, by country, EU/EEA countries, 2011

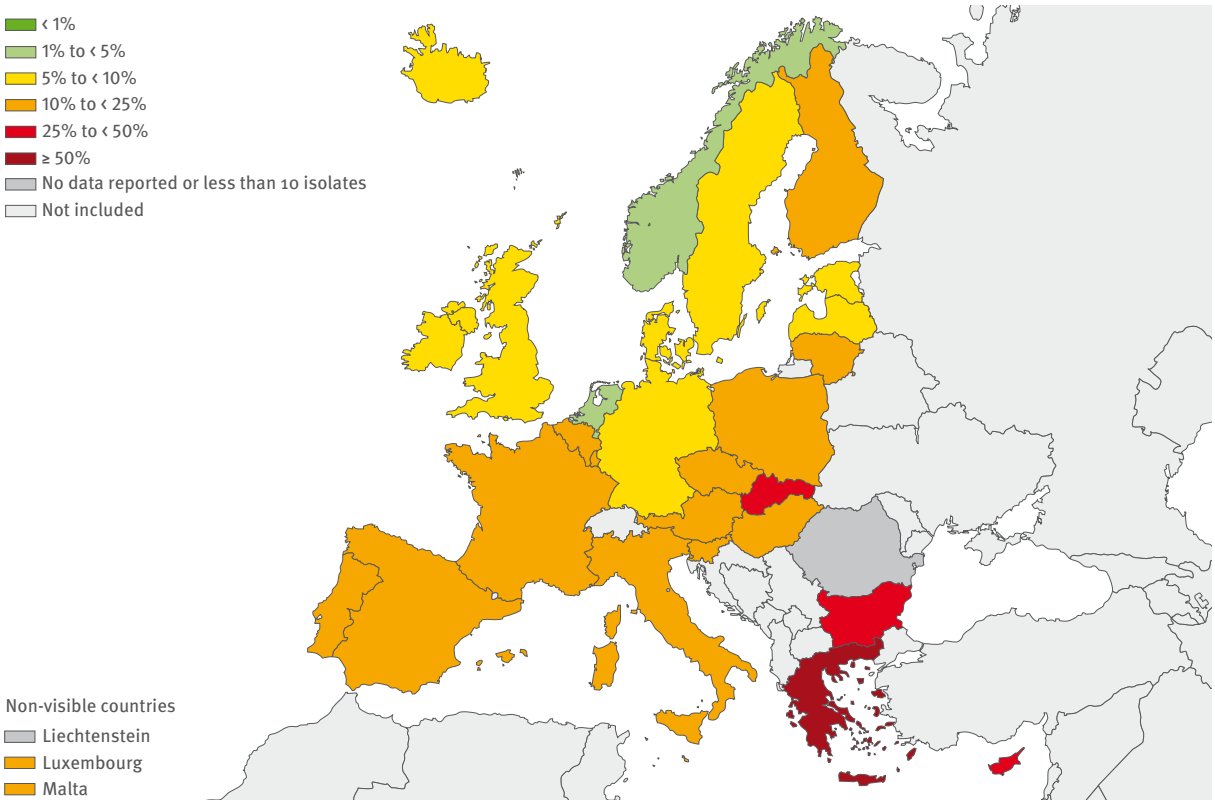


Figure 4.24: *Pseudomonas aeruginosa*: percentage (%) of invasive isolates with combined resistance (resistance to three or more antimicrobial classes among piperacillin (±tazobactam), ceftazidime, fluoroquinolones, aminoglycosides and carbapenems), by country, EU/EEA countries, 2011

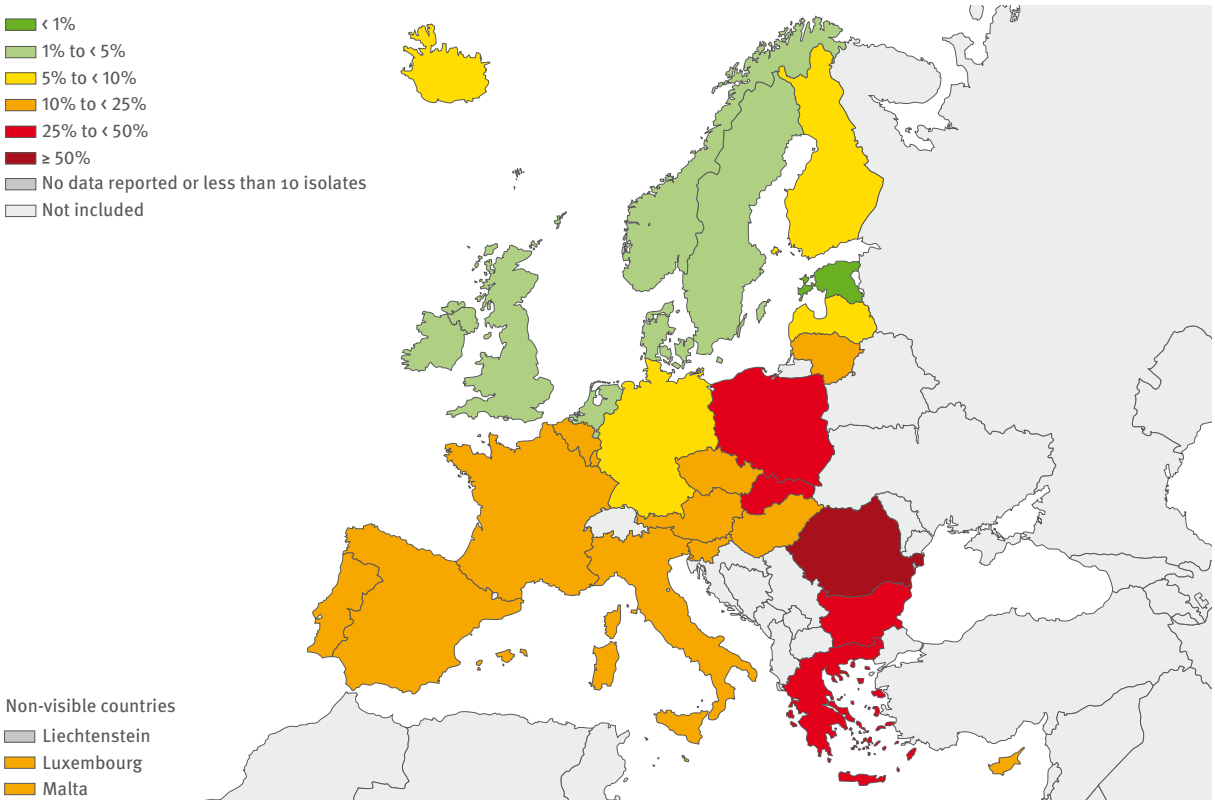
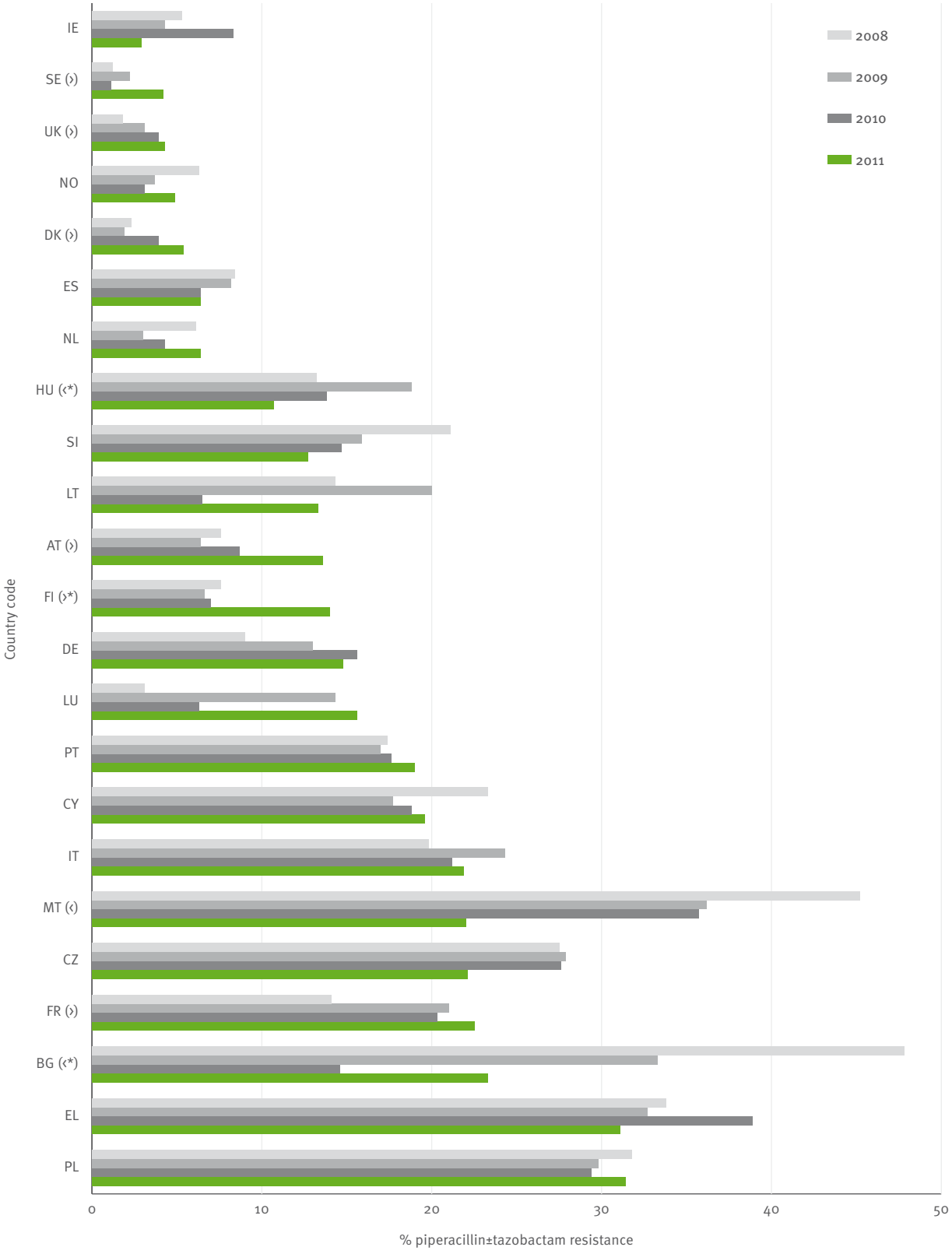
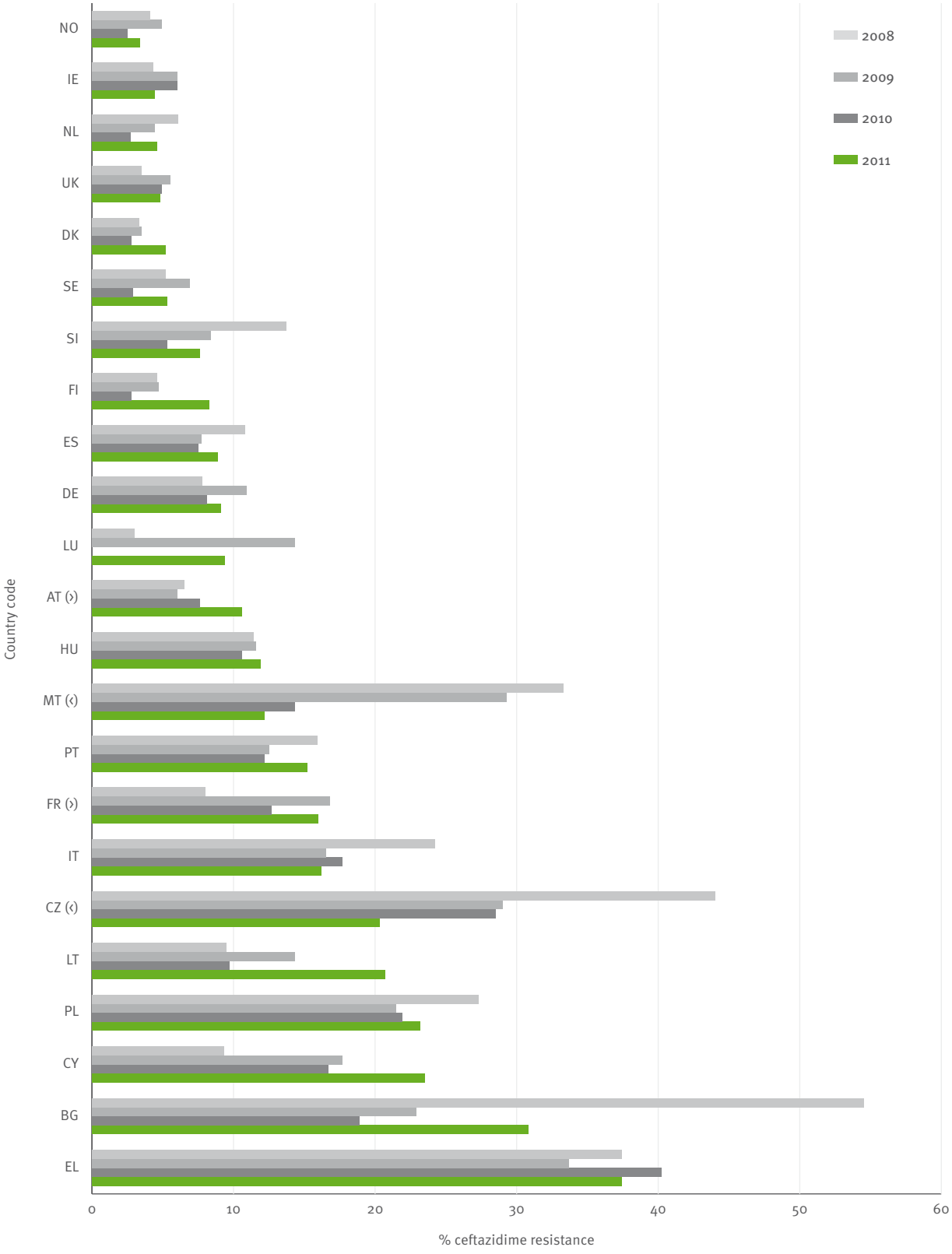


Figure 4.25: ***Pseudomonas aeruginosa*: trends of invasive isolates with resistance to piperacillin±tazobactam, by country, EU/EEA countries, 2008–2011**



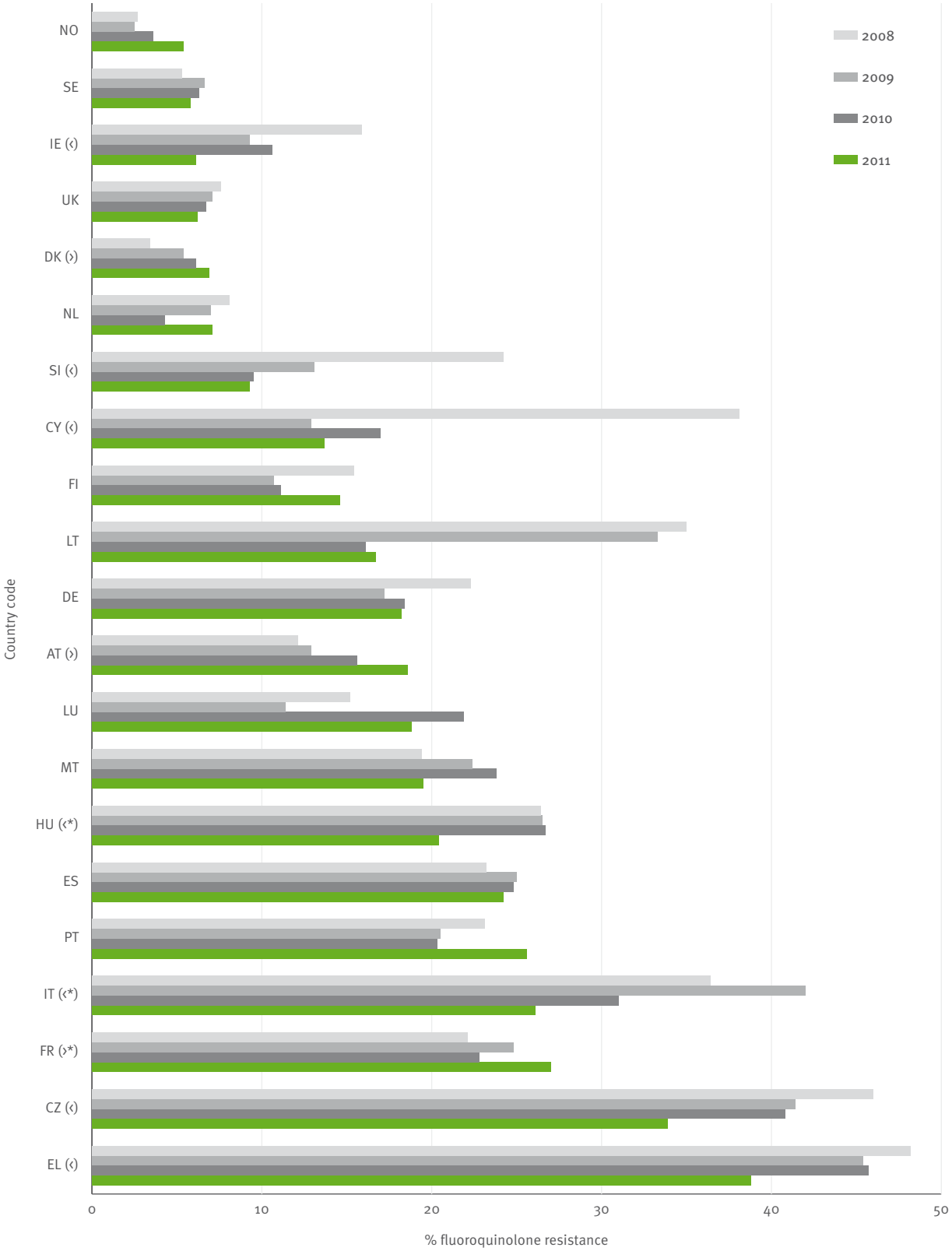
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Estonia, Iceland, Latvia and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.26: *Pseudomonas aeruginosa*: trends of invasive isolates with resistance to ceftazidime, by country, EU/EEA countries, 2008–2011



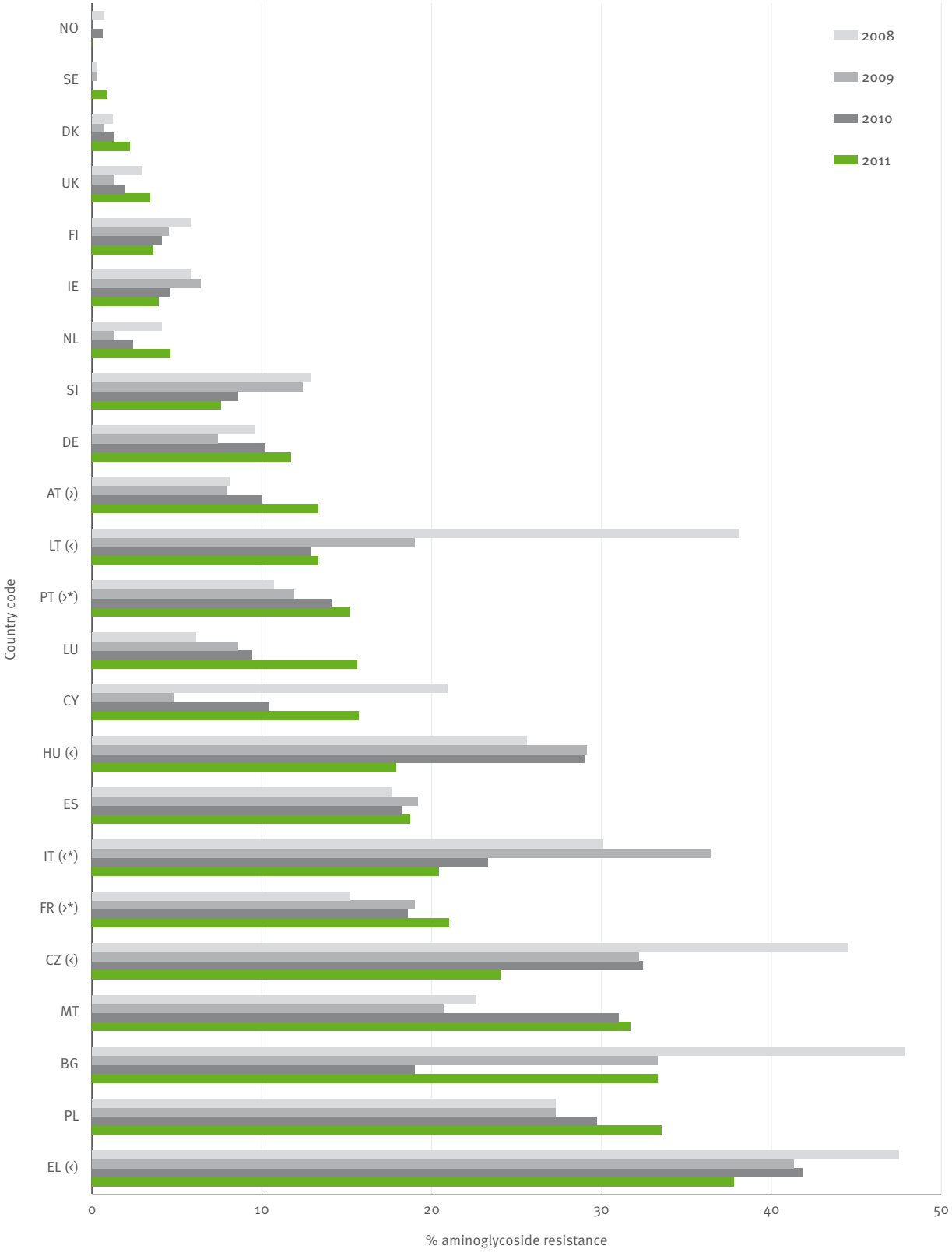
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Estonia, Iceland, Latvia and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively.

Figure 4.27: *Pseudomonas aeruginosa*: trends of invasive isolates with resistance to fluoroquinolones, by country, EU/EEA countries, 2008–2011



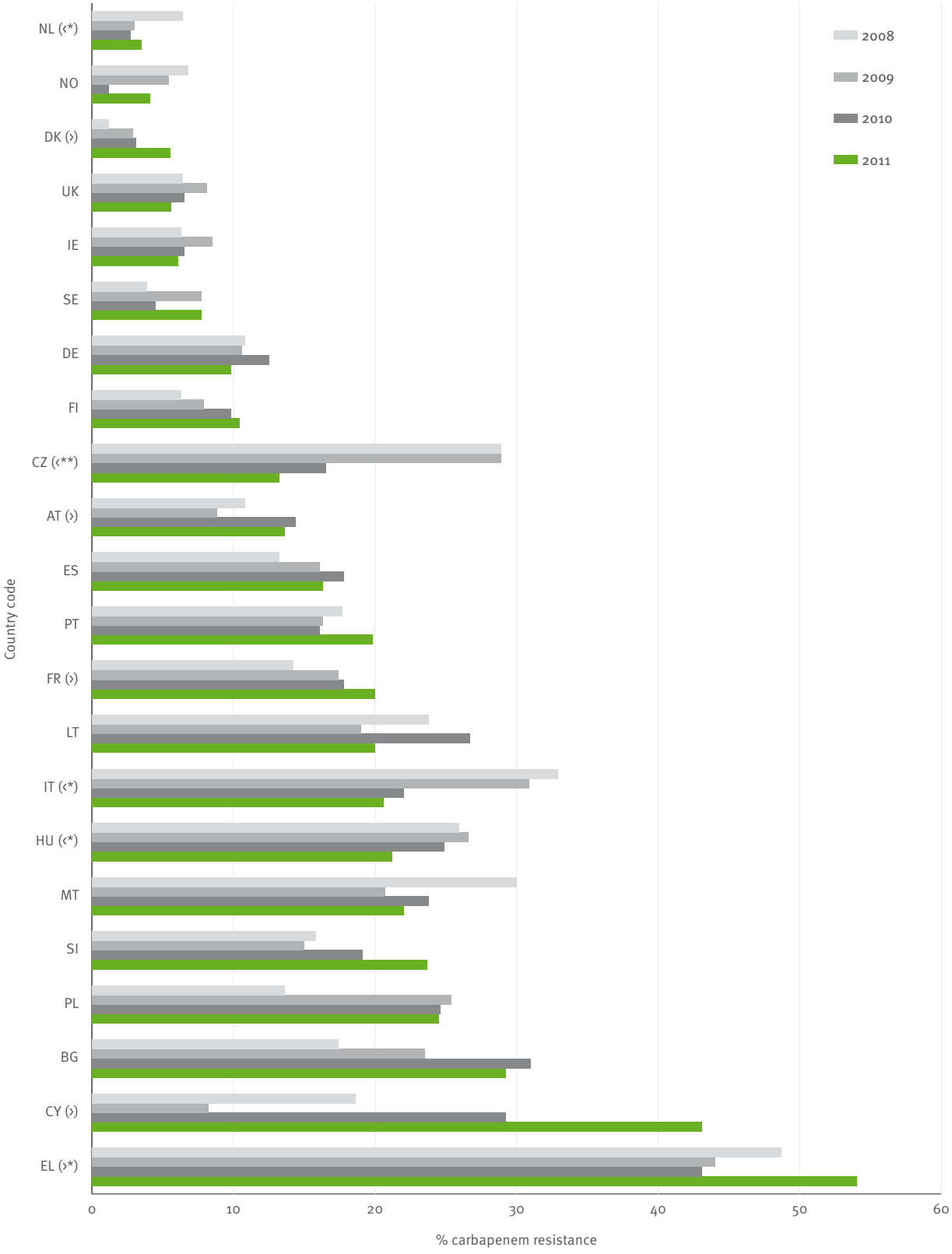
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Bulgaria, Estonia, Iceland, Latvia, Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.28: ***Pseudomonas aeruginosa*****: trends of invasive isolates with resistance to aminoglycosides, by country, EU/EEA countries, 2008–2011**



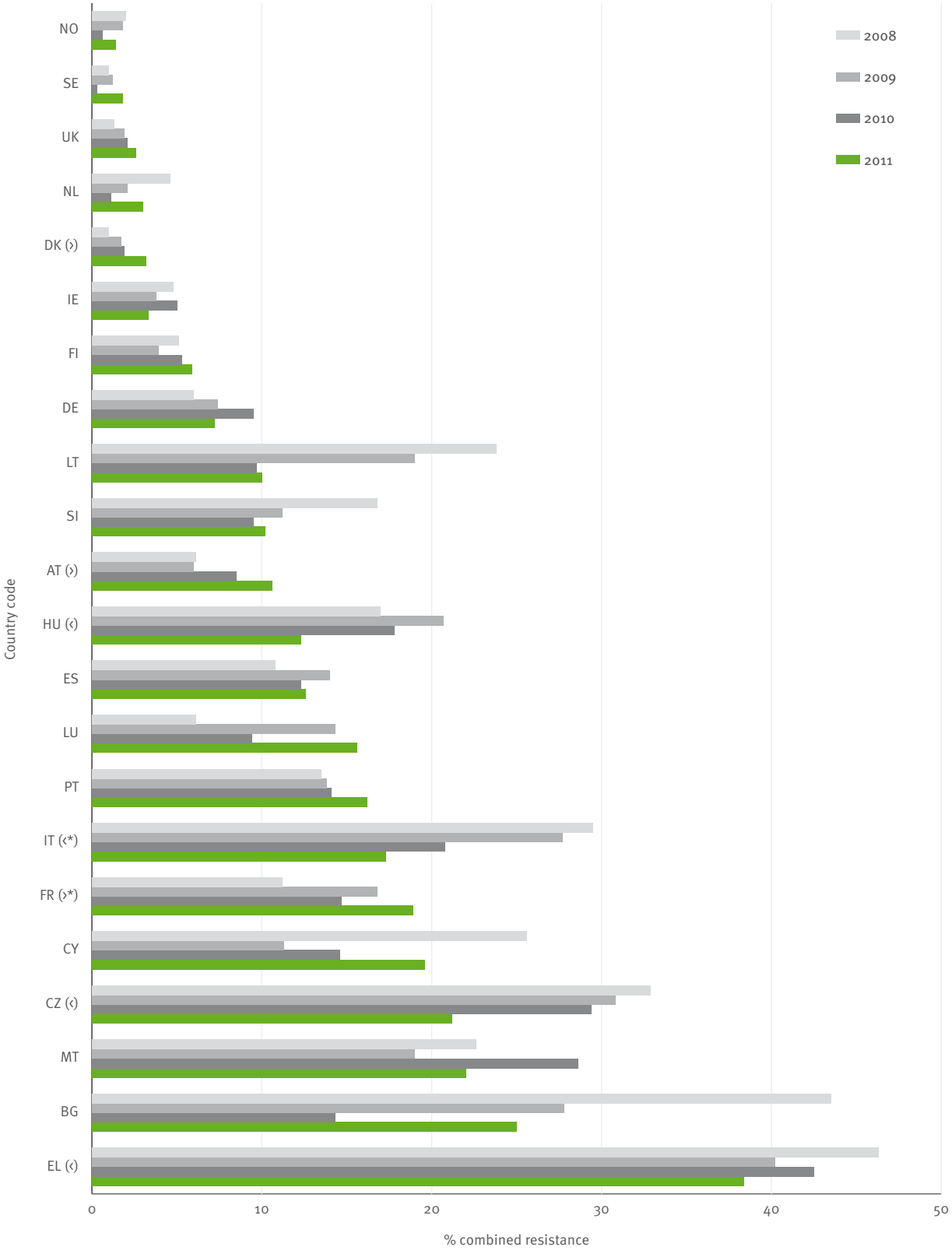
Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Estonia, Iceland, Latvia and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.29: ***Pseudomonas aeruginosa*****: trends of invasive isolates with resistance to carbapenems, by country, EU/EEA countries, 2008–2011**



Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Estonia, Iceland, Latvia, Luxembourg and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.
** For Czech Republic there is a decreasing trend, but the drop in 2010 was caused by the adoption of the new EUCAST breakpoints.

Figure 4.30: ***Pseudomonas aeruginosa*****: trends of invasive isolates with combined resistance (resistant to three or more antibiotic classes among piperacillin±tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems), by country, EU/EEA countries, 2008–2011**



Countries not reporting data for all four years (Belgium and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Estonia, Iceland, Latvia and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

4.4 *Streptococcus pneumoniae*

4.4.1 Clinical and epidemiological importance

Streptococcus pneumoniae is a common cause of disease, especially among young children, elderly people and patients with compromised immune functions. The clinical spectrum ranges from upper airway infections, such as sinusitis, and otitis media to pneumonia and invasive bloodstream infections and meningitis. Since *S. pneumoniae* is the most common cause of pneumonia worldwide, morbidity and mortality are high and annually approximately 3 million people are estimated to die of pneumococcal infections.

Pneumococci carry a variety of virulence factors that facilitate adherence and transcytosis of epithelial cells. The cell wall of pneumococci is coated with a viscous polysaccharide slime layer termed the capsule. This is the most important virulence factor because it protects the bacteria from the adhesion of opsonising antibodies and the destruction by leucocytes. Capsular polysaccharides are highly diverse and play an important role in immune evasion. To date, 93 different serotypes have been described. The serotype distribution varies with age, disease and geographical region. Interestingly, serotypes most frequently involved in pneumococcal disease or colonisation in infants are also most frequently associated with AMR. However, serotype replacement due to increased use of the pneumococcal conjugate vaccine (PCV) might change this over time.

4.4.2 Resistance mechanisms

Beta-lactam antimicrobials bind to cell wall synthesising enzymes, so-called penicillin-binding proteins (PBPs), and interfere with the biosynthesis and remodelling of the bacterial cell wall during cell growth and division. The mechanism of penicillin resistance in *S. pneumoniae* consists of alterations in PBPs, which result in reduced affinity to this class of antimicrobial. Alterations in PBPs are due to a continuous mutation process that causes different degrees of resistance proceeding from reduced susceptibility through low-level clinical resistance – conventionally termed intermediate[i] (I) – to full clinical resistance (R). Intermediately resistant strains are clearly less susceptible than susceptible strains. However, in the absence of meningitis, infections with intermediately resistant strains are often successfully treated with high doses of benzyl-penicillin or aminopenicillins.

Macrolide, lincosamide and streptogramin (MLS) antimicrobials are chemically distinct, but all bind to a ribosomal subunit inhibiting the initiation of mRNA binding and thus act as protein synthesis inhibitors. There are two predominant resistance mechanisms against MLS antimicrobials in *S. pneumoniae*:

i Microorganisms are defined as intermediate by a level of antimicrobial activity with uncertain clinical effect. Occasionally, this can be overcome if antibiotics can be administered at a higher dose and/or are concentrated at the infected body site.

Table 4.9: *Streptococcus pneumoniae*: number of invasive isolates tested for penicillin and macrolides susceptibility, percentage (%) being penicillin-non-susceptible (PNSP), penicillin-resistant (PRSP), macrolide-non-susceptible (MNSP), single penicillin-resistant (PENR), single macrolide-resistant (MACR) and non-susceptible to penicillin and macrolides, including 95% confidence intervals, by country, EU/EEA countries, 2011

Country	Number of isolates tested for (PEN/MACR/both)	%PNSP (95%CI)	%PRSP (95%CI)	%MNSP (95%CI)	%single PEN (95%CI)	%single MACR (95%CI)	%DUAL (95%CI)
Austria	405/373/355	3.0 (2-5)	1.7 (1-4)	11.5 (8-15)	0.8 (0-2)	9.6 (7-13)	2.3 (1-4)
Belgium	1829/1829/1829	0.8 (0-1)	0.8 (0-1)	26.0 (24-28)	0.2 (0-1)	25.4 (23-27)	0.6 (0-1)
Bulgaria	33/30/30	21.2 (9-39)	21.2 (9-39)	13.3 (4-31)	10.0 (2-27)	0.0 (0-12)	13.3 (4-31)
Cyprus	12/12/12	25.0 (5-57)	25.0 (5-57)	25.0 (5-57)	8.3 (0-38)	8.3 (0-38)	16.7 (2-48)
Czech Republic	316/316/316	3.8 (2-7)	0.0 (0-1)	3.5 (2-6)	1.9 (1-4)	1.6 (1-4)	1.9 (1-4)
Denmark	896/896/896	4.8 (3-6)	0.2 (0-1)	5.1 (4-7)	1.8 (1-3)	2.1 (1-3)	3.0 (2-4)
Estonia	51/45/42	2.0 (0-10)	2.0 (0-10)	2.2 (0-12)	2.4 (0-13)	2.4 (0-13)	0.0 (0-8)
France	1413/1413/1413	23.8 (22-26)	0.1 (0-1)	26.0 (24-28)	5.1 (4-6)	7.3 (6-9)	18.8 (17-21)
Germany	347/353/343	1.7 (1-4)	0.3 (0-2)	7.9 (5-11)	1.2 (0-3)	8.2 (5-12)	0.0 (0-1)
Hungary	139/129/129	11.5 (7-18)	5.8 (3-11)	14.7 (9-22)	3.9 (1-9)	6.2 (3-12)	8.5 (4-15)
Iceland	32/32/32	9.4 (2-25)	6.3 (1-21)	21.9 (9-40)	0.0 (0-11)	12.5 (4-29)	9.4 (2-25)
Ireland	324/310/310	19.4 (15-24)	6.2 (4-9)	18.4 (14-23)	5.5 (3-9)	4.8 (3-8)	13.5 (10-18)
Italy	174/266/162	6.9 (4-12)	6.3 (3-11)	27.4 (22-33)	2.5 (1-6)	24.7 (18-32)	4.3 (2-9)
Latvia	40/46/38	12.5 (4-27)	10.0 (3-24)	0.0 (0-8)	13.2 (4-28)	0.0 (0-9)	0.0 (0-9)
Lithuania	48/41/41	18.8 (9-33)	2.1 (0-11)	26.8 (14-43)	4.9 (1-17)	9.8 (3-23)	17.1 (7-32)
Luxembourg	50/52/50	8.0 (2-19)	2.0 (0-11)	15.4 (7-28)	2.0 (0-11)	10.0 (3-22)	6.0 (1-17)
Malta	8/10/8	50.0 (25-73)	10.0 (2-71)	12.5 (0-53)	0.0 (0-71)	0.0 (0-71)	12.5 (0-53)
Netherlands	1067/1200/978	1.1 (1-2)	0.3 (0-1)	4.5 (3-6)	0.7 (0-1)	4.2 (3-6)	0.3 (0-1)
Norway	619/570/567	3.4 (2-5)	0.0 (0-1)	4.2 (3-6)	1.9 (1-3)	2.6 (1-4)	1.4 (1-3)
Poland	165/135/134	18.2 (13-25)	4.2 (2-9)	26.7 (19-35)	3.7 (1-8)	11.9 (7-19)	14.9 (9-22)
Portugal	439/417/402	10.5 (8-14)	8.4 (6-11)	14.9 (12-19)	5.5 (3-8)	9.2 (7-12)	5.2 (3-8)
Romania	36/18/18	61.1 (43-77)	61.1 (43-77)	44.4 (22-69)	16.7 (4-41)	0.0 (0-19)	44.4 (22-69)
Slovak Republic	26/25/25	7.7 (1-25)	3.8 (0-20)	12.0 (3-31)	4.0 (0-20)	8.0 (1-26)	4.0 (0-20)
Slovenia	252/251/251	12.3 (9-17)	0.8 (0-3)	24.3 (19-30)	6.4 (4-10)	18.3 (14-24)	6.0 (3-10)
Spain	736/746/720	30.2 (27-34)	9.8 (8-12)	24.8 (22-28)	13.2 (11-16)	8.3 (6-11)	16.9 (14-20)
Sweden	1013/963/963	3.5 (2-5)	3.2 (2-4)	5.2 (4-7)	1.7 (1-3)	3.2 (2-5)	2.0 (1-3)
United Kingdom	1324/1263/1126	5.4 (4-7)	0.8 (0-1)	5.9 (5-7)	2.7 (2-4)	2.5 (2-4)	3.6 (3-5)

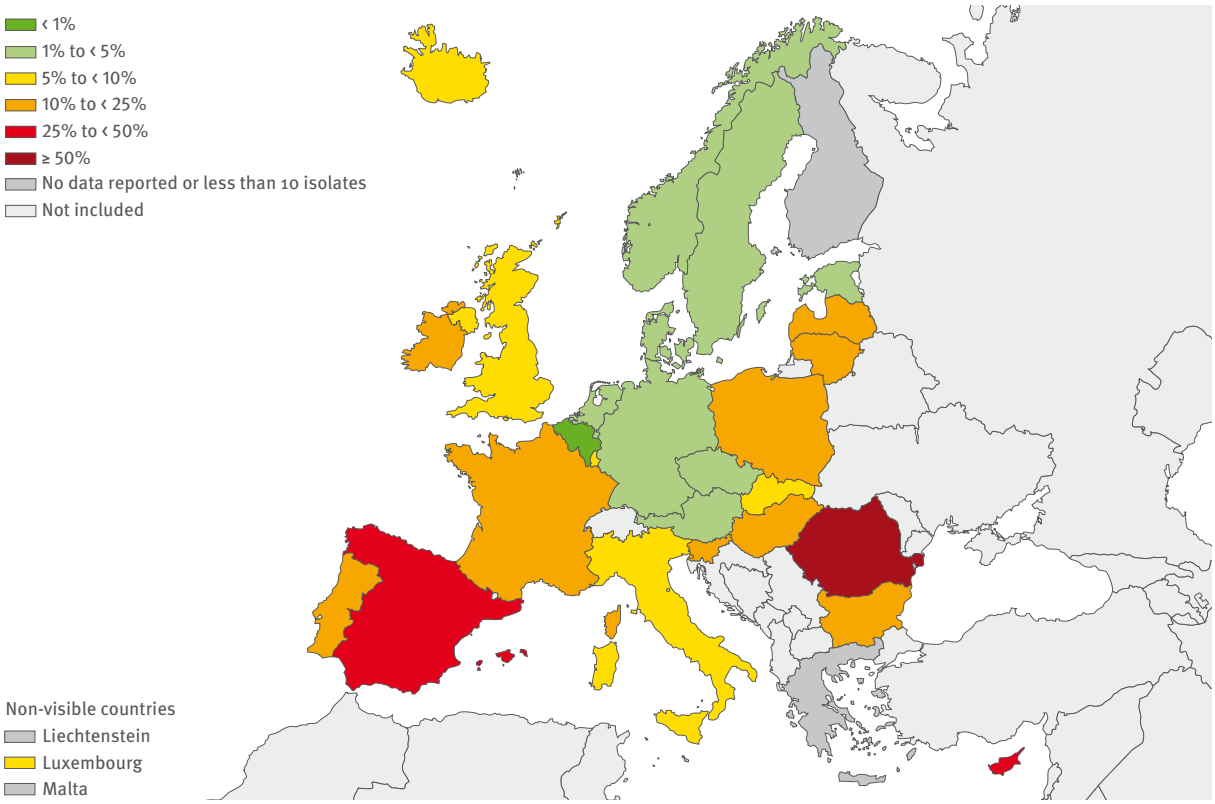
- The acquisition of an erythromycin ribosomal methylation gene (*erm*) results in a post-transcriptional modification of the 23S subunit of ribosomal RNA, which blocks the binding of the macrolide to the ribosome. Once expression of the gene is induced, this often results in high-level resistance (MICs › 128 mg/L) to macrolides, lincosamide and streptogramin B, termed MLS_B resistance.
- The acquisition of a macrolide efflux system gene (*mef*(E)) results in the excretion of the antimicrobial, and effectively reduces intracellular erythromycin, azithromycin and clarithromycin to subinhibitory concentrations. In contrast to beta-lactam resistance, macrolide resistance via these mechanisms (particularly for MLS_B) provides very high MICs, and cannot be overcome by increasing the dosages of antimicrobials.

The two fluoroquinolones with acknowledged clinical activity against pneumococci are levofloxacin and moxifloxacin. Resistance to fluoroquinolones is mediated by the mutations in ParC (subunit of topoisomerase IV) and/or GyrA (subunit of DNA gyrase/topoisomerase IV). Additionally, resistance may be conferred by efflux.

Since *S. pneumoniae* is the most frequent cause of community-acquired pneumonia and cannot clinically be easily distinguished from lower airway infections caused by other pathogens, empirical treatment of community-acquired lower respiratory infections needs to be active against pneumococci and should take the local prevalence of AMR into account. Prescription of non-beta-lactam compounds is therefore typical in countries where penicillin non-susceptibility has been frequently reported. Such prescribing patterns increase the selection pressure for alternative antimicrobials such as macrolides and fluoroquinolones. It is therefore no surprise to see a dynamic AMR picture emerge in different European countries. At the same time, the existence of frequent dual beta-lactam/macrolide resistance, particularly among serotypes commonly found in children, means that in practice the use of agents from either of these classes will result in increasing percentages of resistance to the other class and frequent use of macrolides has been considered as a major driver for the increase in beta-lactam resistance.

Even though a certain small decrease in penicillin resistance had been detected in some countries before the introduction of the PCV, the widespread use of this vaccine is an important factor that may have influenced the decrease in AMR levels, eliminating the infections (and more importantly, the children's carriage) of frequent 'classic' resistant serotypes – 14, 6B, 19F and 23F – all of them covered by the PCV.

Figure 4.31: ***Streptococcus pneumoniae*****: percentage (%) of invasive isolates non-susceptible to penicillin (PNSP), by country, EU/EEA countries 2011**



4.4.3 Results

Penicillin

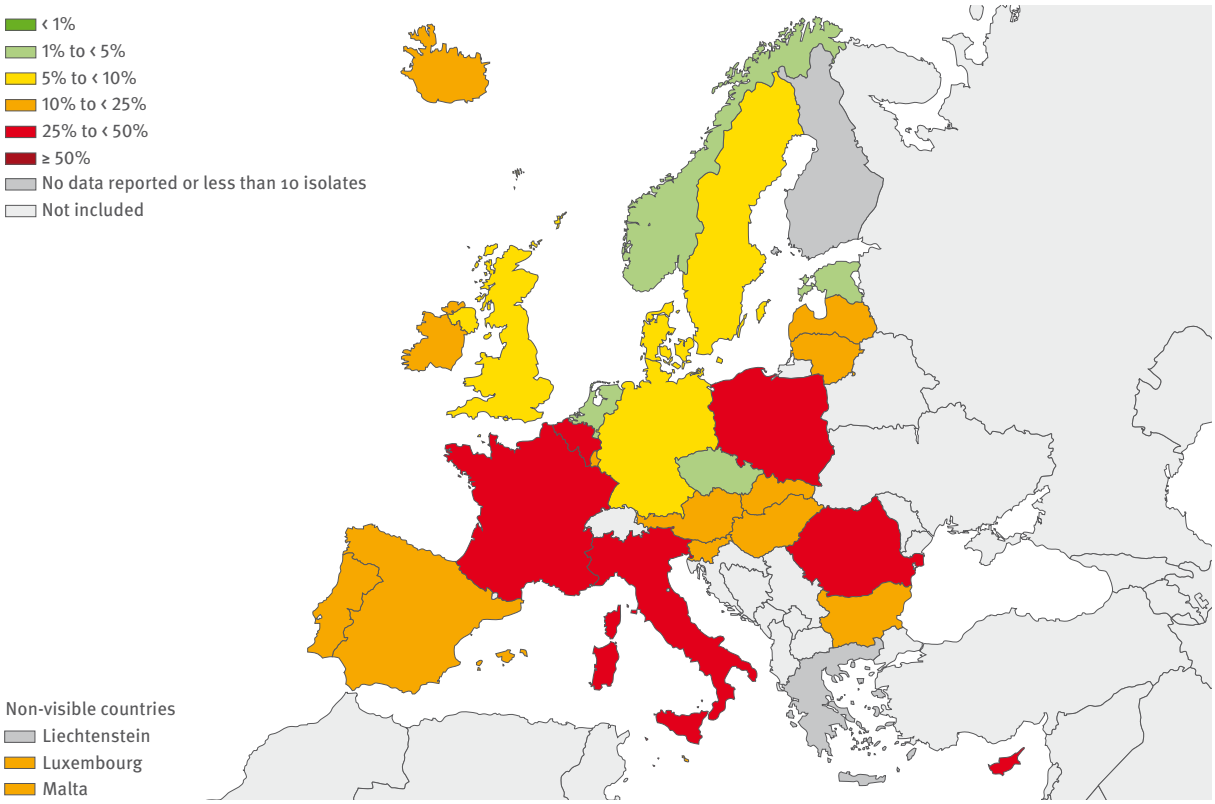
- For 2011, 27 countries reported 11788 isolates, of which 1039 (8.8%) were non-susceptible to penicillin and 268 of these non-susceptible isolates were identified as resistant. Greece and Finland did not report data for 2011 and Malta reported fewer than 10 isolates (accordingly no data from these countries are displayed in Figure 4.31).
- For 2011, the number of reported *S. pneumoniae* isolates with relevant AST information for penicillin (penicillins or oxacillin) ranged between 8 (Malta) and 1829 (Belgium) (Table 4.9).
- The percentage of isolates reported as non-susceptible was below 1% in one country, 1–5% in eight countries, 5–10% in five countries, 10–25% in nine countries, 25–50% in three countries and above 50% in one country (Figure 4.31 and Table 4.9).
- Trends for the period 2008–2011 were calculated for 22 countries. Four countries (Denmark, Estonia, Lithuania and Sweden) had significantly increasing trends (Figure 4.35).
- Significantly decreasing trends were observed for four countries (Belgium*[i], Portugal, Hungary, and France). For France and Portugal, the trends did not remain significant when considering only data from laboratories reporting consistently for all four years (Figure 4.35).

Macrolides

- For 2011, 27 countries reported 11739 isolates, of which 1713 (14.6%) were non-susceptible to macrolides and 1658 of these non-susceptible isolates were identified as resistant (14.1% of total isolates).
- The number of reported *S. pneumoniae* isolates with relevant AST information for macrolides (erythromycin, clarithromycin or azitromycin) ranged between 10 (Malta) and 1829 (Belgium) (Table 4.9).
- The percentage of isolates reported as non-susceptible ranged from zero (Latvia) to 44.4% (Romania), and was reported below 5% in five countries, 5–10% in four countries, 10–25% in 11 countries, and 25–50% in seven countries (Figure 4.32, Table 4.9).

i The percentage of *Streptococcus pneumoniae* non-susceptible to penicillin reported by Belgium dropped from 8% in 2008 to < 1% in 2009. This is largely due to the fact that the clinical breakpoints (CLSI) used to determine SIR have changed. These new CLSI guidelines started to be used in the beginning of 2009.

Figure 4.32: *Streptococcus pneumoniae*: percentage (%) of invasive isolates non-susceptible to macrolides by country, EU/EEA countries, 2011



- Trends for the period 2008–2011 were calculated for 21 countries. Significantly increasing trends were observed for Lithuania, Slovenia and Spain. For Spain, the trend did not remain significant when considering only data from laboratories reporting consistently throughout the period (Figure 4.36).
- Significantly decreasing trends were observed for three countries (Hungary, Norway and Portugal) (Figure 4.36).

Non-susceptibility to penicillins and macrolides

- For 2011, 27 countries reported 11184 isolates tested for both penicillin and macrolides, of which 652 (5.8%) isolates were non-susceptible to both antimicrobial classes. One country (Malta) reported fewer than 10 isolates and is therefore not included in Figure 4.33.
- The number of reported *S. pneumoniae* isolates with relevant AST information for both penicillins and macrolides ranged between 8 (Malta) and 1829 (Belgium) (Table 4.9).
- Percentages of non-susceptibility to penicillin and macrolides ranged from zero (Estonia, Germany and Latvia) to 44.4% (Romania), and were reported below 1% in five countries, 1–5% in eight countries, 5–10% in five countries 10–25% in eight countries, and 25–50% in one country (Figure 4.33 and Table 4.9).
- Trends for 2008–2011 were calculated for 21 countries. A significant increase was observed for four countries (Denmark, Lithuania, Spain and Sweden) (Figure 4.37).
- Significantly decreasing trends were observed for five countries (Belgium, Germany, Hungary, France and Portugal) (Figure 4.37).

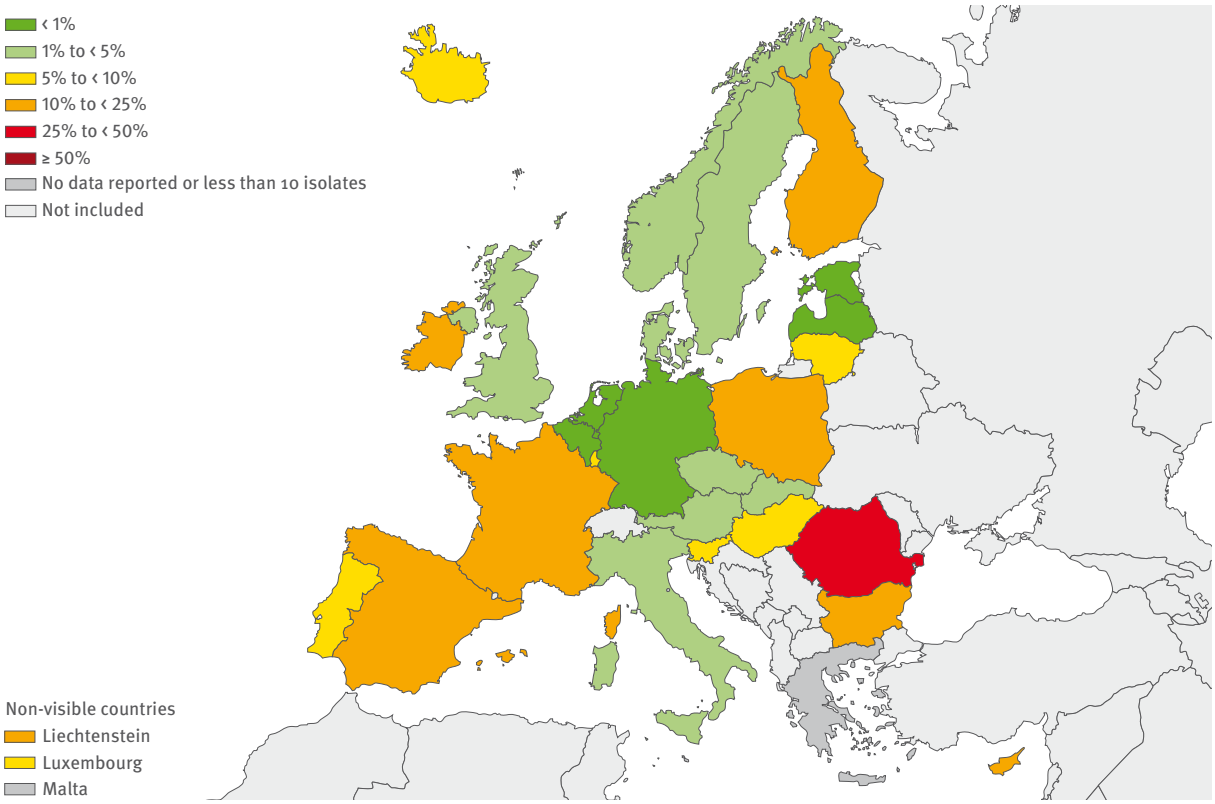
Fluoroquinolones

- For 2011, 24 countries reported susceptibility data for fluoroquinolones in 7275 isolates (58% of all reported *S. pneumoniae* isolates). Among them, 4.8% were resistant to fluoroquinolones. Forty fluoroquinolone-resistant isolates were also penicillin-non-susceptible.

Serogroups

- Fifteen countries reported 3855 *S. pneumoniae* isolates with identification of the serotype/serogroup. Cyprus, Germany, Poland, Romania and Slovakia reported fewer than 30 isolates with serotype/serogroup information and are hence not included in the analysis.
- In 2011, serogroups 1 and 19 were the most prevalent serogroups (accounting for 14% and 13% of the isolates, respectively), followed by serogroup 7 (12%) and serogroup 3 (9%). This serogroup distribution is similar to the one reported by EARS-Net in 2010.

Figure 4.33: *Streptococcus pneumoniae*: percentage (%) of invasive isolates non-susceptible to penicillins and macrolides by country, EU/EEA countries, 2011



- Among the most commonly reported serogroups, dual non-susceptibility to both penicillin and macrolides was mainly observed in serogroups 19, 14, 6, 15 and 9 (by order of decreasing percentage). Single non-susceptibility to penicillin was most common in serogroups 19, 14, 9 and 23, and single non-susceptibility to macrolides was most common in serogroups 19, 1, 14 and 6 (Figure 4.34).

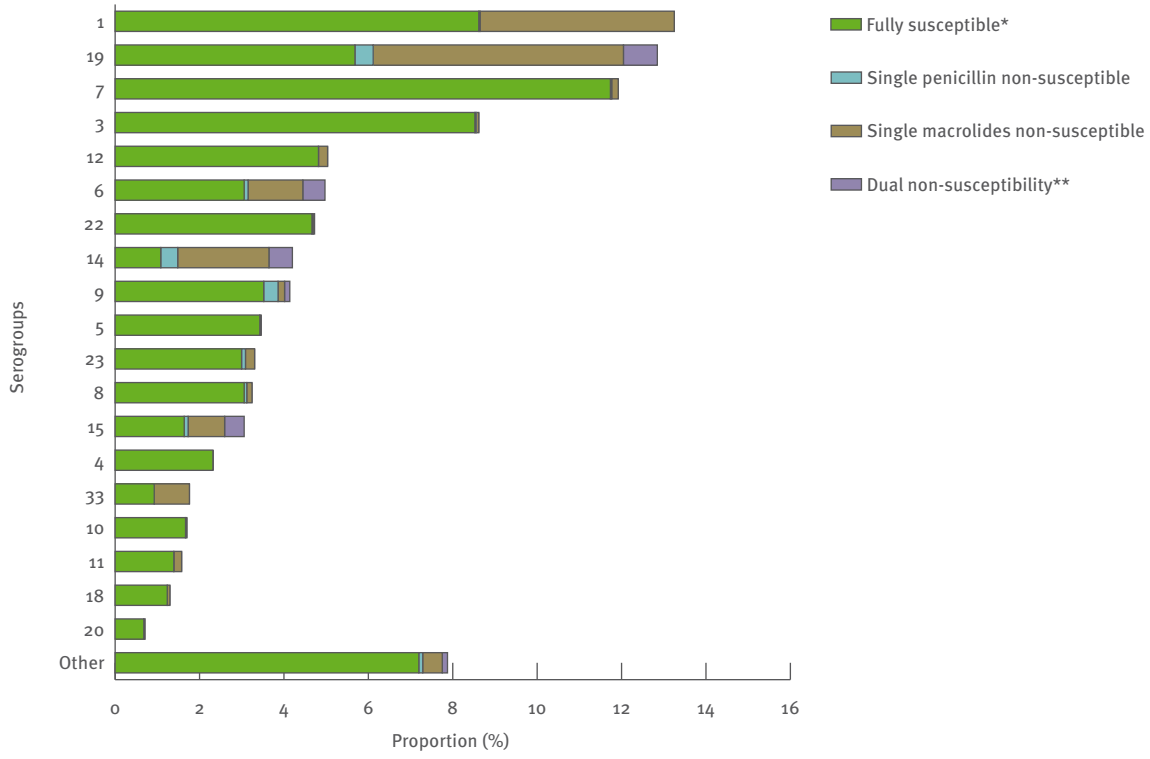
4.4.4 Discussion and conclusions

Although large inter-country variations can be noted, the overall percentages of *S. pneumoniae* with non-susceptibility to commonly used antimicrobials reported to EARS-Net have remained relatively stable in Europe during recent years. The lowest percentages of *S. pneumoniae* with non-susceptibility to penicillin and/or macrolides were reported by countries in central and northern Europe. Geographical differences in reported percentages of resistant *S. pneumoniae* have been shown, in several studies, to be associated with differences in antimicrobial consumption, both on individual and population levels[26]. A previous ecological study linking data collected by the former EARSS with national data on antimicrobial consumption, supported this assumption[27]. In addition, differences in serotype distributions and local dominance of specific clones may also influence national estimates[25].

It is important to note that the differences and changes in clinical breakpoints used for determining penicillin susceptibility in *S. pneumoniae* might introduce bias when comparing national data reported to EARS-Net, but also when interpreting trends in countries that changed clinical breakpoints during the observation period. Similar surveillance artefacts have been reported from the United States when *S. pneumoniae* data were analysed with new breakpoints[28].

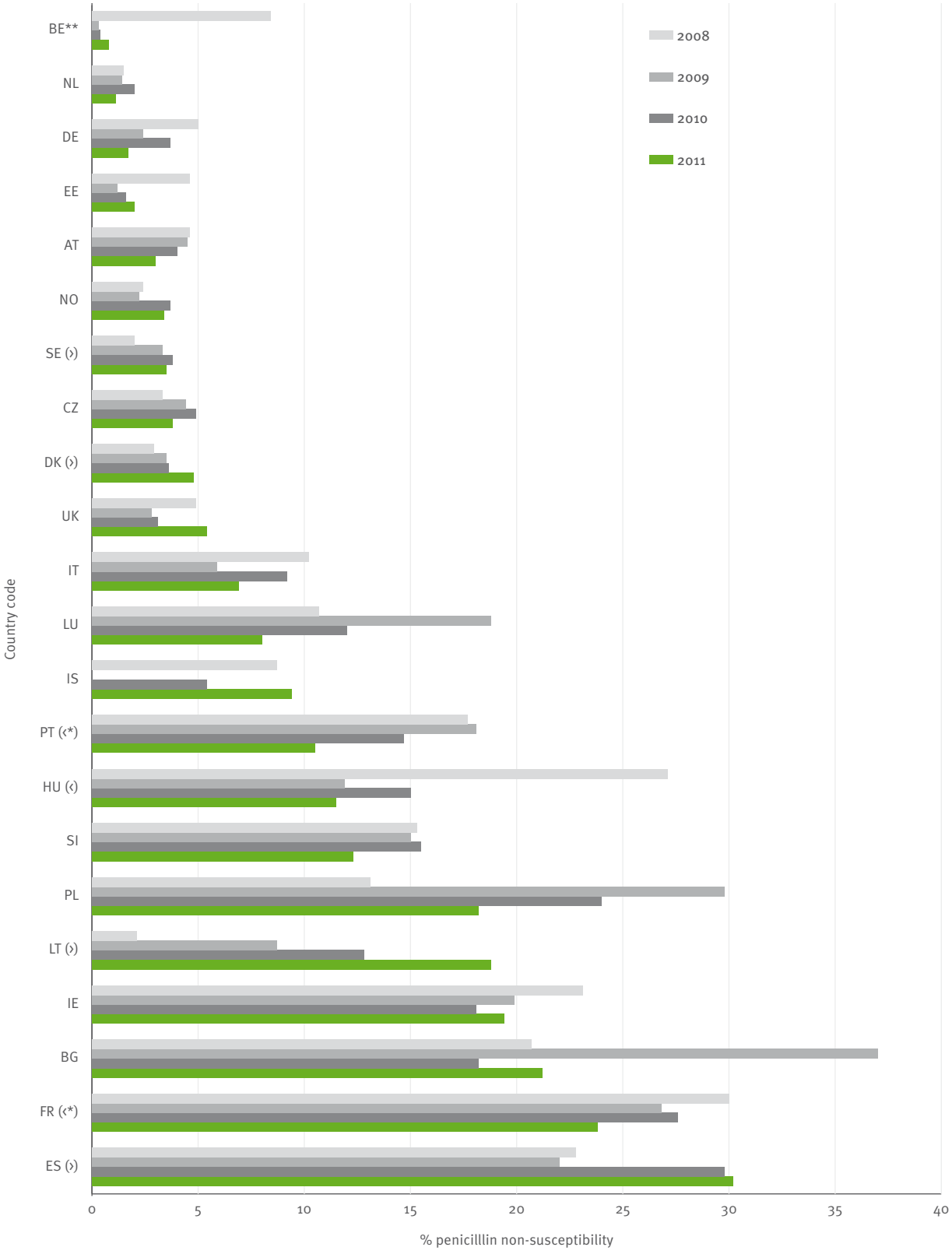
Although the number of countries reporting data on serotype distribution to EARS-Net is increasing, data remain incomplete. However, data reported for 2011 support previous observations that most penicillin non-susceptible isolates belong to a few serogroups. Most EU/EEA Member States have, in recent years, implemented routine immunisation for children with the multivalent PCV[29]. As a limited number of *S. pneumoniae* serotypes are responsible for a considerable percentage of serious pneumococcal infections in both adults and children, introduction of PCV is likely to change the epidemiology of invasive pneumococcal disease in many European countries.

Figure 4.34: Distribution of serogroups and associated resistance profiles per serogroup, 2011



Only countries that reported serogroup information for more than 30 isolates were included in the figure.
* Susceptible to at least penicillin and macrolides.
** Non-susceptible to penicillin and macrolides.

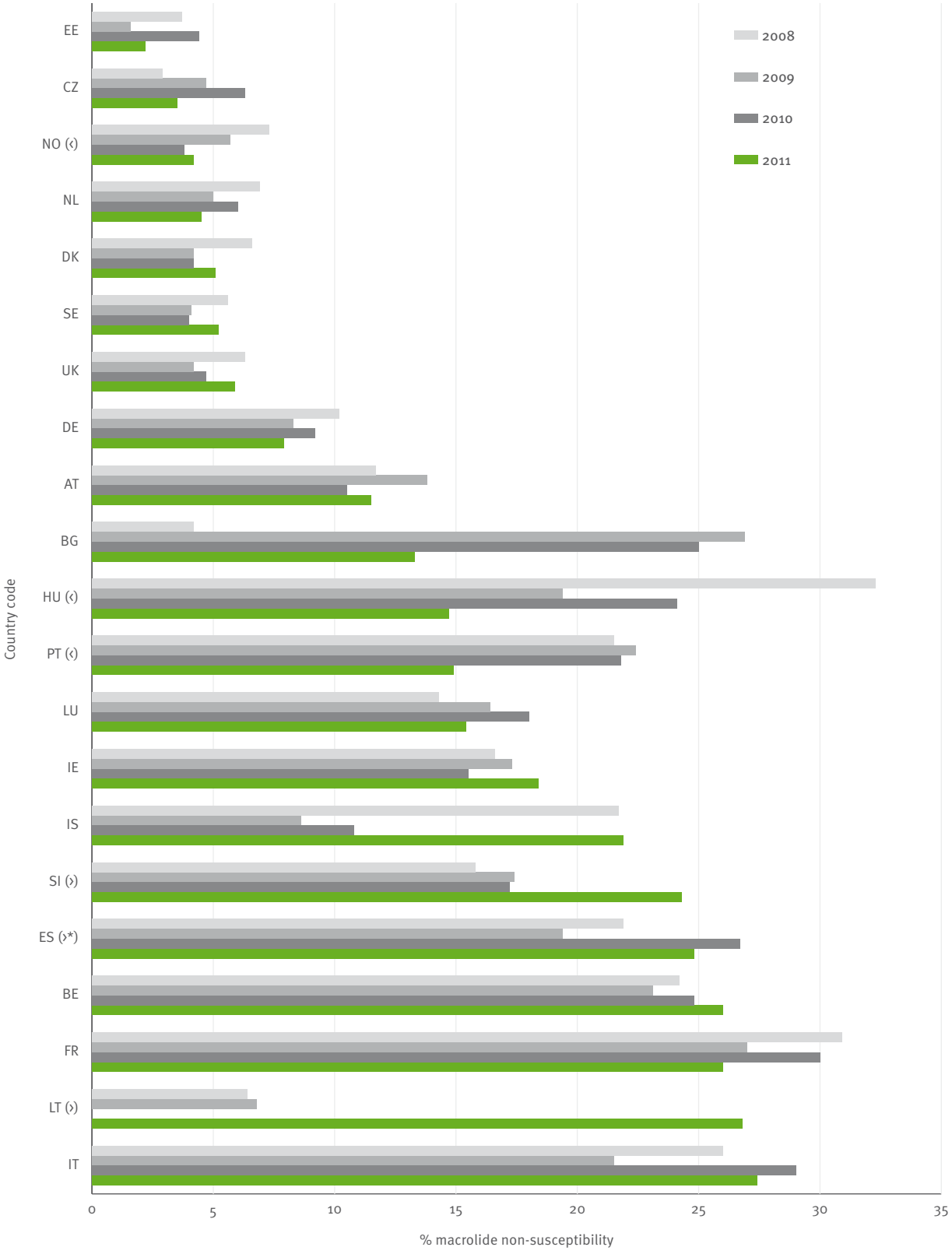
Figure 4.35: *Streptococcus pneumoniae*: trends of invasive isolates with non-susceptibility to penicillin, by country, EU/EEA countries, 2008–2011



Countries not reporting data for all four years (Finland, Greece and Slovakia) and countries only reporting relevant AST data for 19 isolates or fewer per year (Cyprus, Latvia, Malta and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

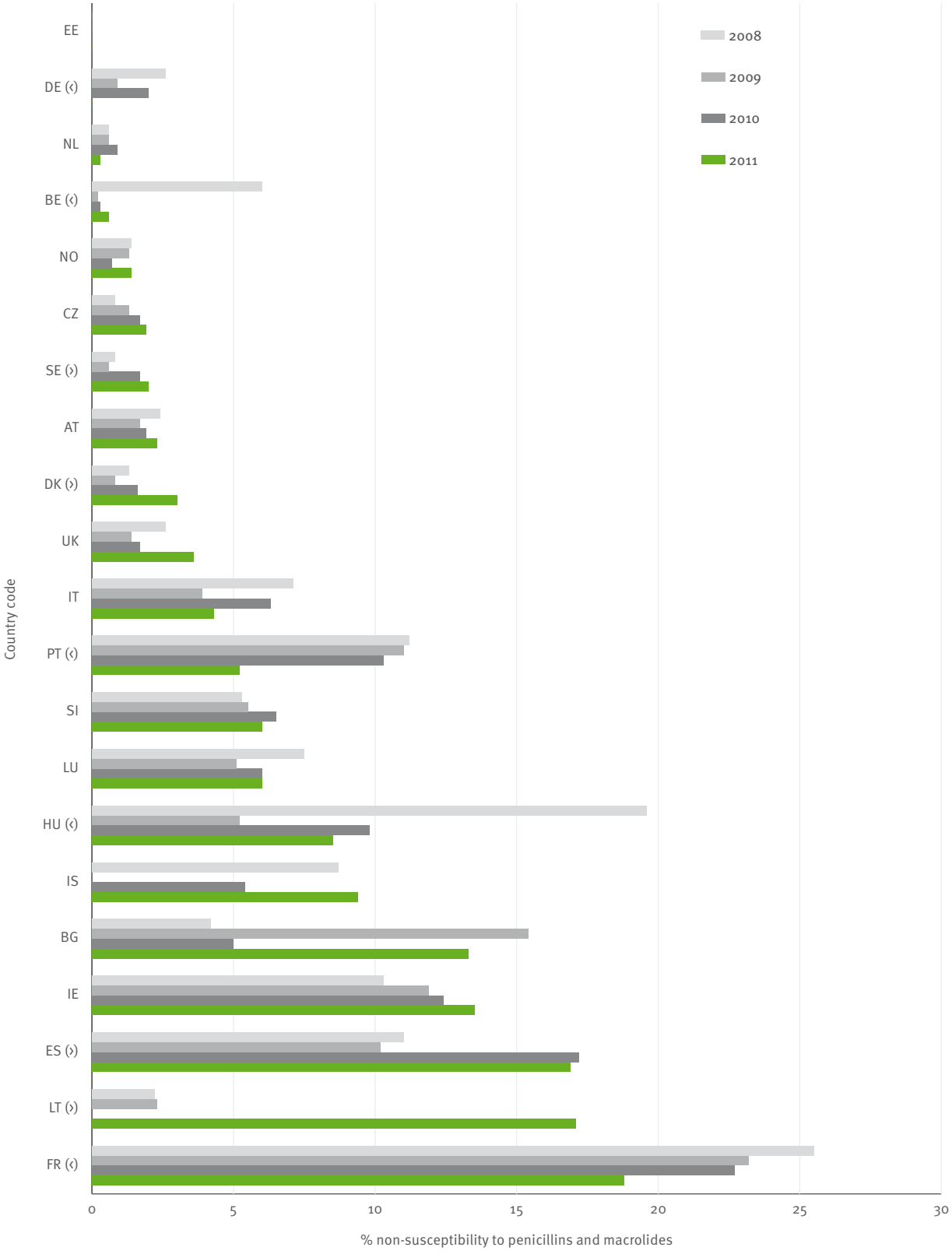
** The percentage of *Streptococcus pneumoniae* non-susceptible to penicillin reported by Belgium dropped from 8% in 2008 to ‹ 1% in 2009. This is largely due to the fact that the clinical breakpoints (CLSI) used to determine SIR have changed. These new CLSI guidelines began to be used in the beginning of 2009.

Figure 4.36: ***Streptococcus pneumoniae*: trends of invasive isolates with non-susceptibility to macrolides, by country, EU/EEA countries, 2008–2011**



Countries not reporting data for all four years (Finland, Greece and Slovakia) and countries only reporting relevant AST data for 19 isolates or fewer per year (Cyprus, Latvia, Malta, Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

Figure 4.37: ***Streptococcus pneumoniae*: trends of invasive isolates with non-susceptibility to penicillins and macrolides, by country, EU/EEA countries, 2008–2011**



Countries not reporting data for all four years (Finland, Greece and Slovakia) and countries only reporting relevant AST data for 19 isolates or fewer per year (Cyprus, Latvia, Malta, Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively.

4.5 *Staphylococcus aureus*

4.5.1 Clinical and epidemiological importance

Staphylococcus aureus is a gram-positive organism that colonises the skin of about 30% of healthy humans. Although mainly a harmless coloniser, *S. aureus* can cause severe infection. Its oxacillin-resistant form (meticillin-resistant *S. aureus*, MRSA) has been the most important cause of antimicrobial-resistant healthcare-associated infections worldwide. Since healthcare-associated MRSA infections add to the number of infections caused by meticillin-susceptible *S. aureus*, a high incidence of MRSA adds to the overall burden of infections caused by *S. aureus* in hospitals. Moreover, infections with MRSA may result in prolonged hospital stay and in higher mortality, owing mainly to the inferior effectiveness of alternative treatment regimens. MRSA is still the most commonly identified antimicrobial-resistant pathogen in hospitals in many parts of the world, including Europe, the Americas, North Africa and the Middle- and Far East.

4.5.2 Resistance mechanisms

Staphylococcus aureus acquires resistance to meticillin and all other beta-lactam antimicrobials through expression of exogenous *mecA* gene that code for a variant penicillin-binding protein PBP2' (PBP2a) with low affinity for beta-lactams, thus preventing the inhibition by beta-lactams of cell wall synthesis. A new *mec* gene has been discovered, *mecC* (formerly called $mecA_{lga251}$). The level of meticillin resistance, as defined by the MIC depends on the amount of PBP2' production, which is influenced by various genetic factors. Resistance levels of *mec*-positive strains can thus range from phenotypically susceptible to highly resistant. Upon challenge with beta-lactam antimicrobials, a population of a heterogeneously resistant MRSA strain may quickly be outgrown by a sub-population of highly resistant variants.

For rifampicin, the mechanism of resistance is mutation in the rpoB-gene, leading to production of RNA polymerase with low affinity for rifampicin and other rifamycins. Such resistance easily occurs with rifampicin monotherapy, for which reason the drug should only be used in combination therapy.

Resistance to fluoroquinolones is mediated by the mutations in ParC or ParE (subunits of topoisomerase IV) and/or GyrA (subunit of DNA gyrase/topoisomerase IV). Additionally, resistance may be conferred by efflux.

The most common mechanism of linezolid resistance is mutation in the 23S rRNA target site. A more recent mechanism is nonmutational and involves acquisition of a natural resistance gene, *cfr* (chloramphenicol–florfenicol resistance). The *cfr* gene has been found primarily in plasmids that can be spread horizontally. The product of the *cfr* gene is a methyltransferase that catalyses methylation of the 23S rRNA gene.

Table 4.10: *Staphylococcus aureus*: number and percentage (%) of invasive isolates resistant to meticillin (MRSA) and rifampicin, including 95% confidence intervals, by country, EU/EEA countries, 2011

Country	Meticillin		Rifampicin	
	Number of isolates tested	% MRSA (95%CI)	Number of isolates tested	% rifampicin-resistant (95%CI)
Austria	1966	7.4 (6-9)	1850	0.3 (0-1)
Belgium	1744	17.4 (16-19)	1014	0.6 (0-1)
Bulgaria	214	22.4 (17-29)	162	14.2 (9-21)
Cyprus	113	41.6 (32-51)	113	0.0 (0-3)
Czech Republic	1555	14.5 (13-16)	782	1.8 (1-3)
Denmark	1452	1.2 (1-2)	1452	0.1 (0-0)
Estonia	116	1.7 (0-6)	3	0.0 (0-71)
France	4716	20.1 (19-21)	4278	1.0 (1-1)
Germany	2388	16.1 (15-18)	1656	0.7 (0-1)
Greece	784	39.2 (36-43)	0	.
Hungary	1156	26.2 (24-29)	570	0.4 (0-1)
Iceland	71	2.8 (0-10)	3	0.0 (0-71)
Ireland	1057	23.7 (21-26)	835	1.0 (0-2)
Italy	1261	38.2 (36-41)	970	4.3 (3-6)
Latvia	192	9.9 (6-15)	186	0.5 (0-3)
Lithuania	278	5.4 (3-9)	158	0.6 (0-2)
Luxembourg	127	20.5 (14-29)	90	0.0 (0-4)
Malta	130	49.2 (41-59)	130	0.8 (0-4)
Netherlands	1801	1.4 (1-2)	1581	0.4 (0-1)
Norway	1223	0.3 (0-1)	446	0.0 (0-1)
Poland	860	24.3 (21-27)	135	27.4 (20-36)
Portugal	1307	54.6 (52-57)	1092	1.7 (1-3)
Romania	107	50.5 (41-60)	101	7.9 (3-15)
Slovakia	560	25.9 (22-30)	478	1.3 (0-3)
Slovenia	464	7.1 (5-10)	443	0.5 (0-2)
Spain	1950	22.5 (21-24)	1826	0.5 (0-1)
Sweden	3099	0.8 (1-1)	2456	0.2 (0-1)
United Kingdom	3408	13.6 (13-15)	1777	0.6 (0-1)

4.5.3 Results

Beta-lactams

- For 2011, 28 countries reported 34 099 isolates, of which 5703 (16.7%) were identified as meticillin-resistant *S. aureus* (MRSA). The number of isolates reported per country ranged from 71 to 4716.
- The percentage of isolates with relevant AST information reported as MRSA ranged from 0.3% (Norway) to 54.6% (Portugal). Two countries reported percentages below 1%, four countries reported 1–5%, four countries reported 5–10%, 10 countries reported 10–25%, six countries reported 25–50%, and two countries reported above 50% (Figure 4.38 and Table 4.10).
- Trends for the period 2008–2011 were calculated for 27 countries. Significantly increasing trends were observed for four countries (Hungary, Luxembourg, Poland, and Romania). For Poland and Romania, the trends did not remain significant when considering only data from laboratories reporting consistently throughout all four years (Figure 4.39).
- Significantly decreasing trends were observed for six countries (Belgium, France, Germany, Ireland, Spain and United Kingdom) (Figure 4.39).

Rifampicin

- For 2011, 27 countries reported 24 587 isolates, of which 262 (1.1%) were identified as resistant to rifampicin. Twenty-two of these countries reported at least one rifampicin-resistant isolate. Sixty-five percent of the rifampicin-resistant isolates were also MRSA. The percentage of rifampicin resistance was 3.0% among the MRSA isolates and 0.4% among the MSSA isolates.
- The percentage of isolates that were resistant was below 1% in 18 countries, 1–5% in six countries, 5–10% in one country, 10–25% in one country, and above 25% in one country (Table 4.10).

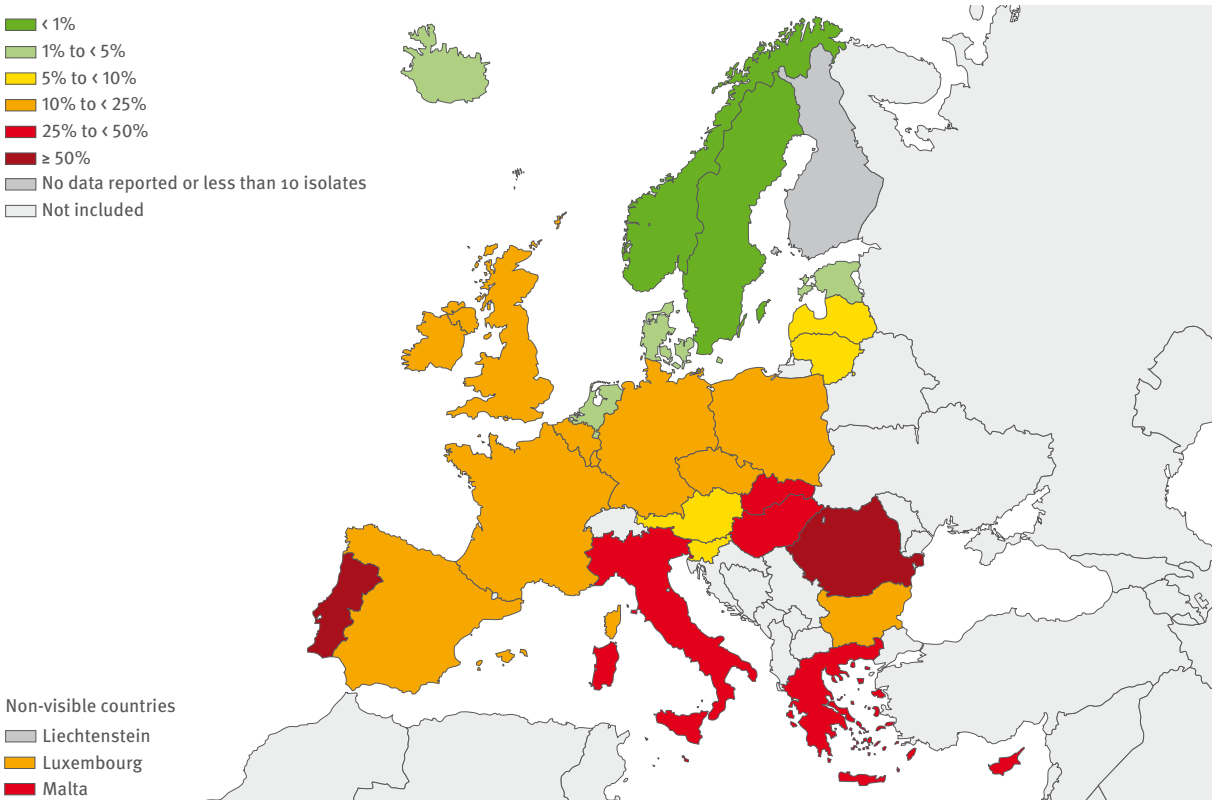
Fluoroquinolones

- For 2011, 26 countries reported AST data for at least one fluoroquinolone in 23 336 isolates. Among them, 4854 (20.8%) were non-susceptible to fluoroquinolones. Sixteen percent (3637/23 108) of all *S. aureus* isolates reported with relevant AST information were non-susceptible to both meticillin and fluoroquinolones. Eighty-five percent of the MRSA isolates with relevant AST data (3637/4265) were resistant to fluoroquinolones.

Linezolid

- For 2011, 26 countries reported susceptibility data for 22 653 *S. aureus* isolates, of which 14 (0.06%) were non-susceptible to linezolid.

Figure 4.38: *Staphylococcus aureus*: percentage (%) of invasive isolates resistant to meticillin (MRSA), by country, EU/EEA countries, 2008–2011

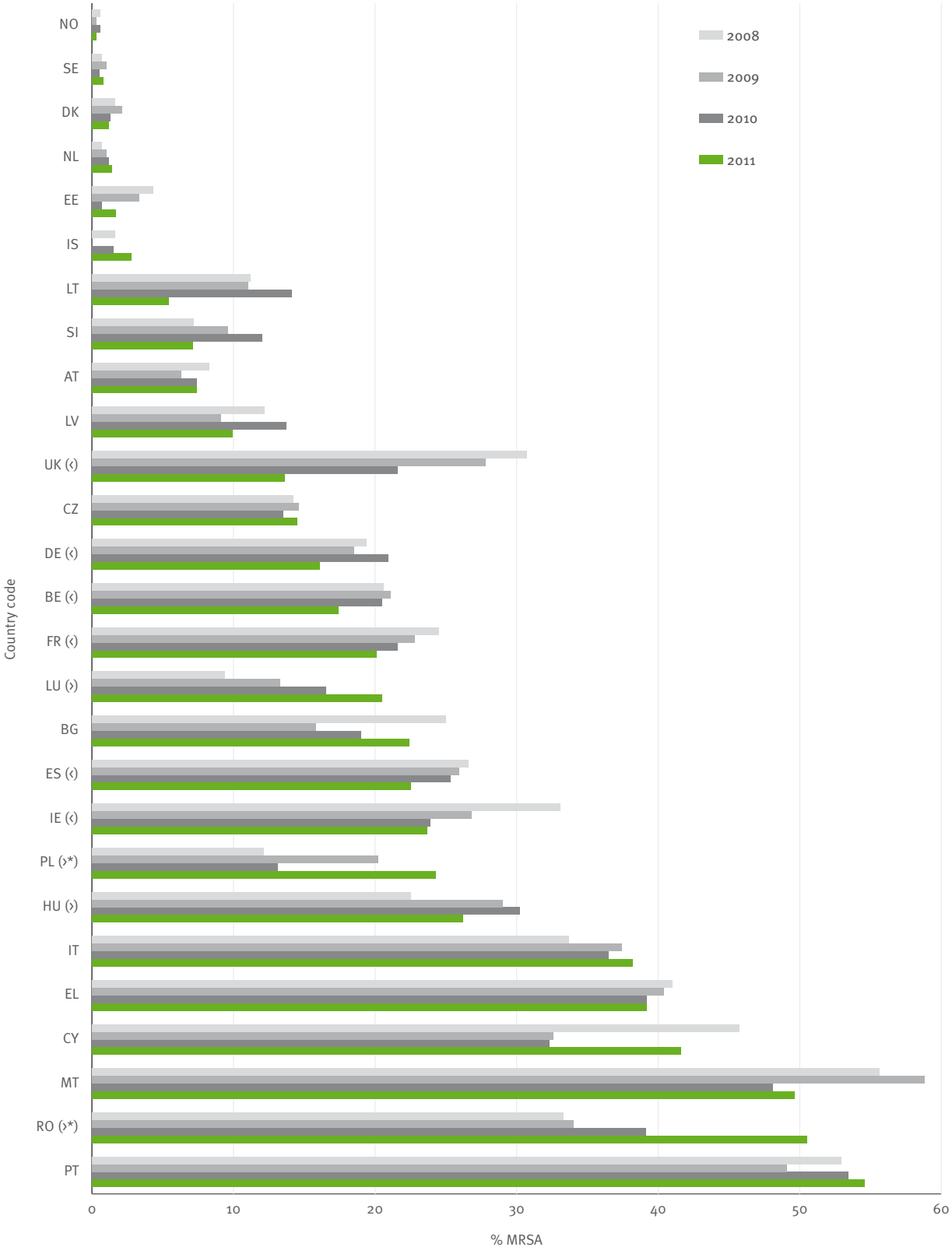


4.5.4 Discussion and conclusions

Data for 2011 reported to EARS-Net show that MRSA percentages continued to decrease or stabilise in most European countries. This is consistent with what has been reported from a number of European national surveillance programmes and scientific studies in recent years[30–32]. In several studies, the decrease has been attributed to improved infection control routines[33–35]. In addition, the decay of some of the dominant MRSA clones might also have influenced the epidemiology of MRSA in Europe[36].

Although these observations provide reasons for optimism, MRSA remains a public health priority, as the percentage of MRSA remains above 25% in eight out of 28 countries, mainly in southern and eastern Europe. To continue to reduce the spread of MRSA in Europe, comprehensive MRSA strategies targeting all healthcare sectors (acute, long-term care facilities and ambulatory care) remain essential.

Figure 4.39: ***Staphylococcus aureus*****: trends of invasive isolates resistant to meticillin (MRSA), by country, EU/EEA countries, 2008–2011**



Countries not reporting data for all four years (Finland and Slovakia) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

4.6 Enterococci

4.6.1 Clinical and epidemiological importance

Enterococci belong to the normal bacterial flora of the gastrointestinal tract of humans, other mammals, birds and reptiles. Enterococci are regarded harmless commensals, and are even believed to have positive effects on a number of gastrointestinal and systemic conditions. However, when the commensal relationship with the host is disrupted, enterococci can cause invasive diseases. Recently, the recognition of high-risk clones suggests that some particular strains can act as true pathogens, and not only as opportunistic commensals. Enterococci can cause a variety of infections, including endocarditis, bloodstream infections, and urinary tract infections, and are associated with peritonitis and intra-abdominal abscesses. In the United States, three to four nosocomial bloodstream infections per 10 000 hospital discharges are caused by enterococci, and contribute to patient mortality as well as additional hospital stay.

The vast majority of clinical enterococcal infections in humans are caused by *Enterococcus faecalis* and *E. faecium*. Epidemiological data collected over the last two decades have documented the emergence of enterococci as important nosocomial pathogens, exemplified by the expansion of a major hospital-adapted polyclonal subcluster CC17 in *E. faecium*, and by CC2 and CC9 in *E. faecalis*. The latter clones have even been isolated from farm animals. The emergence of particular clones and clonal complexes of *E. faecalis* and *E. faecium* was paralleled by increases in resistance to glycopeptides and high-level resistance to aminoglycosides. These two antimicrobial classes represent the few remaining therapeutic options for treatment of human infections caused by *E. faecium* when resistance has emerged against penicillins. Besides the fact that infections caused by resistant strains are difficult to treat, enterococci are highly tenacious and thus easily disseminate in the hospital setting.

4.6.2 Resistance mechanisms

Enterococci are intrinsically resistant to a broad range of antimicrobials including cephalosporins, sulphonamides and low concentrations of aminoglycosides. Patient safety in hospitals is challenged by the ability of enterococci to acquire additional resistance through the transfer of plasmids and transposons and recombination or mutation.

Beta-lactam antimicrobials

By nature, enterococci have low susceptibility to many beta-lactam antimicrobials as a consequence of their low-affinity PBPs. Two possible mechanisms of resistance of enterococci to beta-lactams have been reported: the production of beta-lactamase, which is an extremely rare finding, and the overproduction and modification of PBPs, particularly PBP5, that causes high-level penicillin resistance in *E. faecium*. Resistance to aminopenicillin is currently rare in *E. faecalis*. Therefore, the

Table 4.11: Total number of invasive isolates and percentages (%) of high-level aminglycoside-resistant *E. faecalis* and vancomycin-resistant *E. faecium*, including 95% confidence intervals, by country, EU/EEA countries, 2011

Country	High-level aminoglycoside resistant *E. faecalis*		Vancomycin-resistant *E. faecium*	
	Number of isolates	% R (95% CI)	Number of isolates	% R (95% CI)
Austria	327	30.9 (26-36)	354	4.5 (3-7)
Belgium	335	18.2 (14-23)	215	7.0 (4-11)
Bulgaria	62	30.6 (20-44)	39	0.0 (0-9)
Cyprus	54	18.5 (9-31)	17	0.0 (0-20)
Czech Republic	556	46.2 (42-50)	211	7.6 (4-12)
Denmark	45	31.1 (18-47)	615	1.3 (1-3)
Estonia	32	19.1 (6-43)	15	0.0 (0-25)
Finland	0	.	169	1.2 (0-4)
France	955	20.0 (18-23)	569	1.4 (1-3)
Germany	578	41.0 (37-45)	535	11.4 (9-14)
Greece	653	37.4 (34-41)	424	23.1 (19-27)
Hungary	461	48.6 (44-53)	120	0.8 (0-5)
Iceland	19	0.0 (0-18)	13	0.0 (0-25)
Ireland	244	29.9 (24-36)	347	34.9 (30-40)
Italy	330	50.0 (44-56)	236	4.2 (2-8)
Latvia	34	26.5 (13-44)	22	9.1 (1-29)
Lithuania	48	43.8 (29-59)	26	7.7 (1-25)
Luxembourg	27	44.4 (25-65)	24	4.2 (0-21)
Malta	0	.	14	0.0 (0-23)
Netherlands	363	33.3 (28-38)	481	1.0 (0-2)
Norway	115	21.7 (15-30)	165	1.8 (0-5)
Poland	190	48.4 (41-56)	202	8.4 (5-13)
Portugal	403	29.8 (25-35)	208	20.2 (15-26)
Romania	0	.	12	0.0 (0-26)
Slovakia	188	49.5 (42-57)	101	4.0 (1-10)
Slovenia	125	36.0 (28-45)	83	0.0 (0-4)
Spain	917	39.3 (36-43)	542	1.5 (1-3)
Sweden	707	19.2 (16-22)	353	0.0 (0-1)
United Kingdom	75	16.0 (9-26)	302	8.9 (6-13)

first choice for treatment of infections caused by this microorganism is still an aminopenicillin such as ampicillin. In *E. faecium*, ampicillin-resistance has increased significantly in recent years not the least due to the wide dissemination of ampicillin-resistant strains belonging to the polyclonal subcluster CC17.

Aminoglycosides

In addition to the intrinsic mechanism of low-level resistance to aminoglycosides, which causes a low uptake of the drug, enterococci have acquired genes conferring high-level resistance to aminoglycosides. High-level resistance to streptomycin can be mediated by single mutations within a protein of the 30S ribosomal subunit, the target of aminoglycoside activity. In addition, different aminoglycoside-modifying enzymes have been identified, targeting eight different aminoglycosides. The bi-functional APH(2'')/AAC(6') enzyme confers high-level resistance to all aminoglycosides except streptomycin and is now widespread across Europe. With high-level resistance, any synergistic effect between beta-lactams and glycopeptides is lost.

Glycopeptides

Vancomycin resistance in enterococci was first reported in France and England, but showed the most dramatic increase in the United States and was attributed to the widespread use of vancomycin in US hospitals. While vancomycin consumption was lower in Europe, a closely related glycopeptide, avoparcin, had been widely used as a growth promoter in animal husbandry since the late 1970s until it was banned in the EU by 1998. Glycopeptide-resistance is due to the synthesis of modified cell wall precursors that show a decreased affinity for glycopeptides. Six phenotypes have been identified of which two have clinical relevance: VanA, with high-level resistance to vancomycin and a variable level of resistance to teicoplanin; and VanB, with a variable level of resistance in most cases to vancomycin only. The VanA and VanB phenotypes, mostly found among *E. faecalis* and *E. faecium*, may be transferred by plasmids and through conjugative transposition.

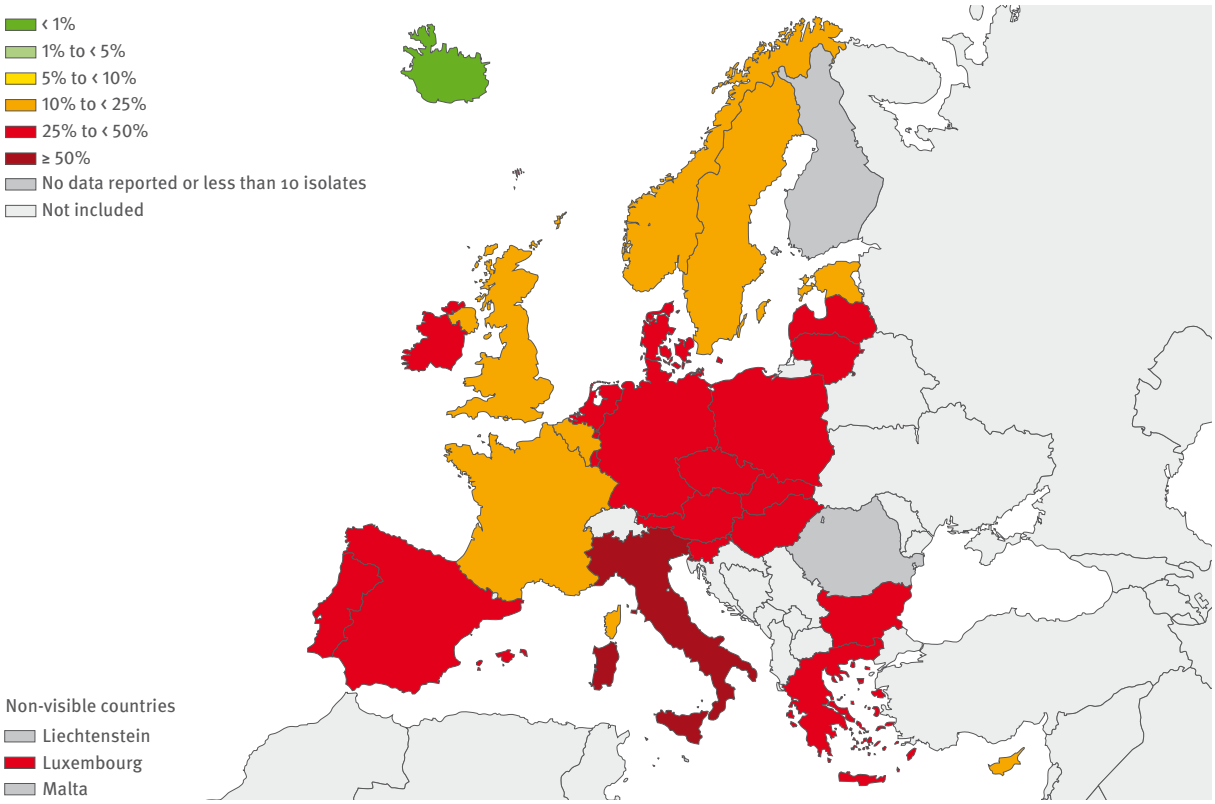
4.6.3 Results

4.6.3.2 *E. faecalis*

High-level aminoglycoside-resistance

- For 2011, 26 countries reported 7843 isolates, of which 2642 (33.7%) had high-level resistance to gentamicin. The number of isolates reported per country ranged from 19 to 955 (Table 4.11).
- The percentages of high-level aminoglycoside-resistance reported by the countries ranged from zero (Iceland) to 50.0% (Italy). One country reported resistance percentages below 1%, seven countries reported 10–25%, and eighteen reported 25–50%. No country reported a percentage above 50% (Figure 4.40 and Table 4.11).

Figure 4.40: *Enterococcus faecalis*: percentage (%) of invasive isolates with high-level resistance to aminoglycosides, by country, EU/EEA countries, 2011



- Twenty countries have reported more than 20 isolates per year since 2008 and were thus included in the trend analysis for the period 2008–2011. Significantly increasing trends were observed for two countries (Austria and Luxembourg) (Figure 4.42).
- Five countries (Belgium, Cyprus, Greece, Portugal, and the United Kingdom) have had significantly decreasing trends of high-level aminoglycoside-resistance for the past four years (Figure 4.42).

4.6.3.3 *E. faecium*

Vancomycin

- For 2011, 29 countries reported 6414 isolates, of which 467 (7.3%) were resistant to vancomycin. The number of isolates with relevant AST information reported per country ranged from 12 to 481. Only one country (Estonia) reported fewer than 10 isolates and is thus not shown in Figure 4.41).
- The percentages of vancomycin-resistant isolates reported by the countries ranged from zero (Bulgaria, Cyprus, Estonia, Iceland, Malta, Romania, Slovenia, and Sweden) to 34.9% (Ireland). Nine countries reported resistance percentages below 1%, ten countries reported 1-5%, six countries reported 5-10%, three countries reported 10-25%, and one country reported above 25% (Figure 4.41 and Table 4.11).
- Twenty countries have reported more than 20 isolates per year since 2008 and were thus included in the trend analysis for the period 2008–2011. Significantly increasing trends were observed only for Germany; however, this trend was not significant when considering only data from laboratories reporting consistently for all four years (Figure 4.43).
- Significantly decreasing trends of vancomycin resistance were observed for four countries (Greece, Sweden, Slovenia and the United Kingdom). For Greece and United Kingdom the trend did not remain significant when considering only data from laboratories reporting consistently for all four years (Figure 4.43).

4.6.4 Discussion and conclusions

High-level aminoglycoside-resistance in *E. faecalis* seems stable in Europe, but at a generally high level with the majority of countries reporting percentages of resistant isolates between 25% and 50%. Several countries (Belgium, Cyprus, Greece, Portugal, and United Kingdom), which previously reported relatively high levels of resistance now have decreasing trends. Likewise, the occurrence of vancomycin-resistance in *E. faecium* is stabilising or decreasing throughout Europe.

Despite these stable trends, high levels of antimicrobial resistant enterococci remain a major infection control challenge in Europe.

Figure 4.41: *Enterococcus faecium*: percentage (%) of invasive isolates resistant to vancomycin, by country, EU/EEA countries, 2011

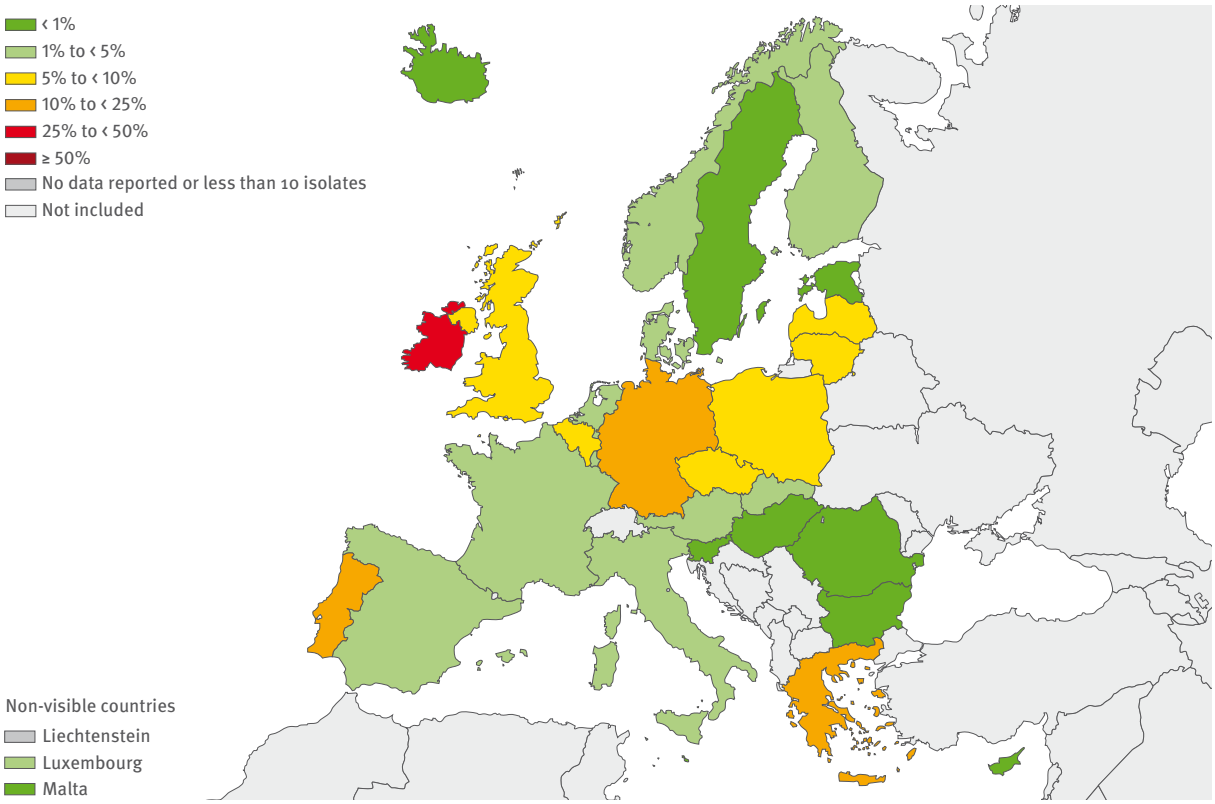
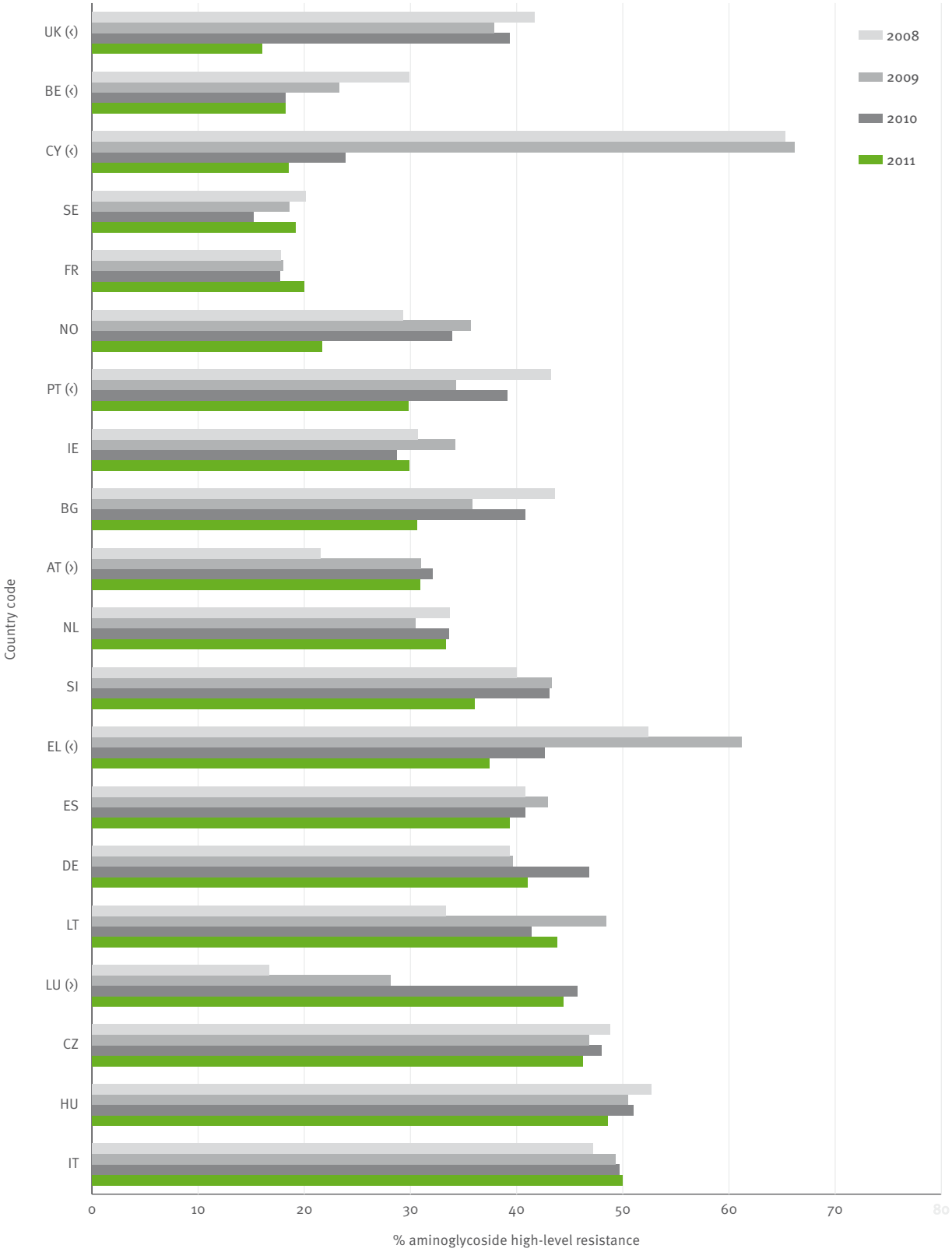
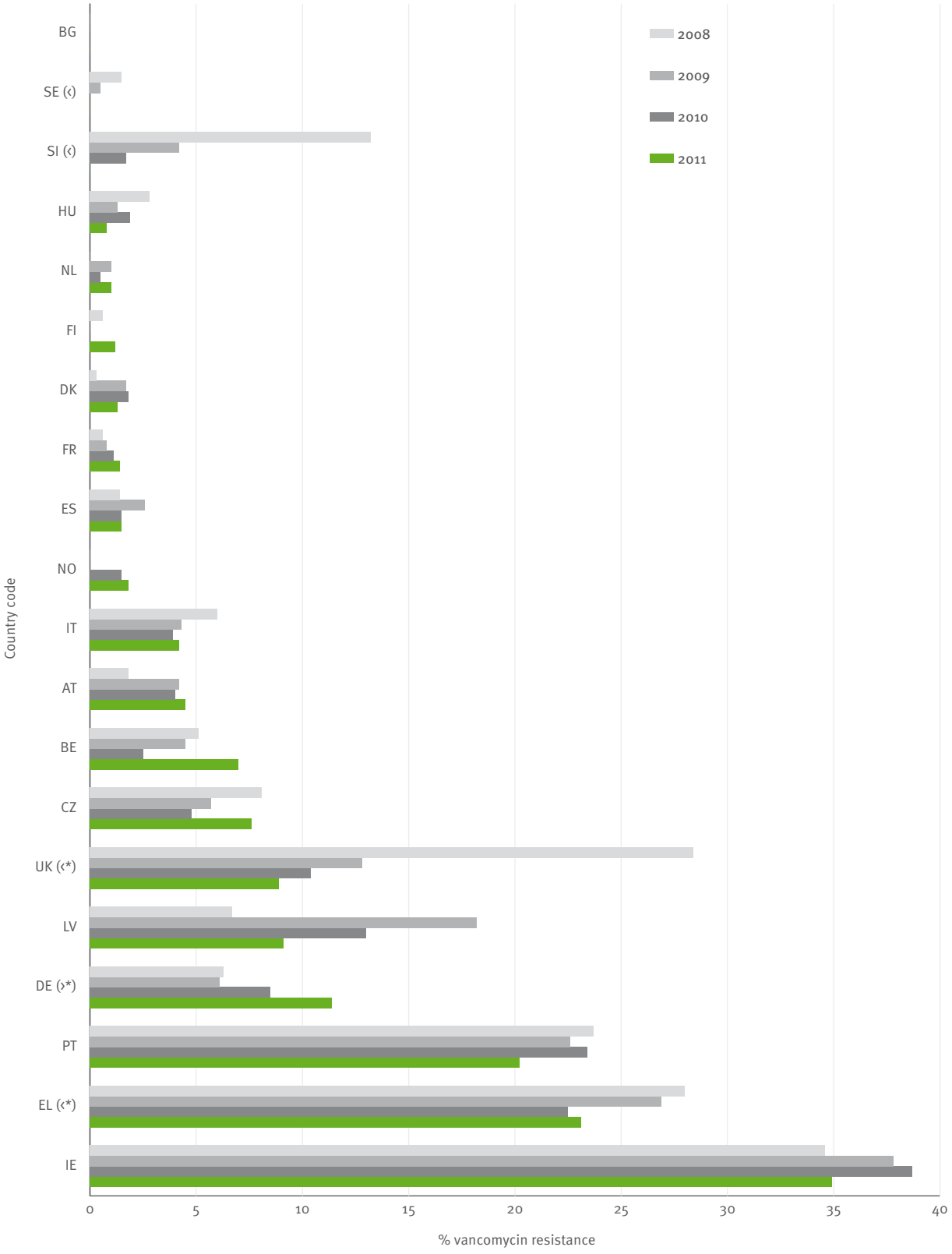


Figure 4.42: *Enterococcus faecalis*: trends of invasive isolates with high-level resistance to aminoglycosides, by country, EU/EEA countries, 2008–2011



Countries not reporting data for all four years (Denmark, Finland, Malta and Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Estonia, Iceland, Latvia, Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively.

Figure 4.43: *Enterococcus faecium*: trends of invasive isolates with resistance to vancomycin, by country, EU/EEA countries, 2008–2011



Countries not reporting data for all four years (Slovakia) and countries reporting relevant AST data for 19 isolates or fewer per year (Cyprus, Estonia, Iceland, Lithuania, Luxembourg, Malta, Poland and Romania) were excluded from the analysis. The symbols › and ‹ indicate significant increasing and decreasing trends, respectively. The asterisks indicate significant trends in the overall data that were not supported by data from laboratories consistently reporting for all four years.

References

1. Ho J, Tambyah PA, Paterson DL. Multiresistant Gram-negative infections: a global perspective. Curr Opin Infect Dis 2010;23(6):546-53.
2. Giske CG, Monnet DL, Cars O, Carmeli Y; ReAct-Action on Antibiotic Resistance. Clinical and economic impact of common multidrug-resistant gram-negative bacilli. Antimicrob Agents Chemother 2008;52(3):813-21.
3. Roberts RR, Hota B, Ahmad I, Scott RD 2nd, Foster SD, Abbasi F, *et al.* Hospital and societal costs of antimicrobial-resistant infections in a Chicago teaching hospital: implications for antibiotic stewardship. Clin Infect Dis 2009;49(8):1175-84.
4. Marchaim D, Gottesman T, Schwartz O, Korem M, Maor Y, Rahav G, *et al.* National multicenter study of predictors and outcomes of bacteremia upon hospital admission caused by *Enterobacteriaceae* producing extended-spectrum beta-lactamases. Antimicrob Agents Chemother 2010;54(12):5099-104.
5. de Kraker ME, Davey PG, Grundmann H; BURDEN study group. Mortality and hospital stay associated with resistant *Staphylococcus aureus* and *Escherichia coli* bacteremia: estimating the burden of antibiotic resistance in Europe. PLoS Med 2011;8(10):e1001104.
6. de Kraker ME, Wolkewitz M, Davey PG, Koller W, Berger J, Nagler J, *et al.* Burden of antimicrobial resistance in European hospitals: excess mortality and length of hospital stay associated with bloodstream infections due to *Escherichia coli* resistant to third-generation cephalosporins. J Antimicrob Chemother 2011; 66(2):398-407.
7. European Centre for Disease Prevention and Control/European Medicines Agency. Joint technical report. The bacterial challenge: time to react—a call to narrow the gap between multidrug-resistant bacteria in the EU and the development of new antibacterial agents. Stockholm:2009;ECDC.
8. Sahuquillo-Arce JM, Selva M, Perpiñán H, Gobernado M, Armero C, López-Quílez A, *et al.* Antimicrobial resistance in more than 100,000 *Escherichia coli* isolates according to culture site and patient age, gender, and location. Antimicrob Agents Chemother 2011;55(3):1222-8.
9. Boyd LB, Atmar RL, Randall GL, Hamill RJ, Steffen D, Zechiedrich L. Increased fluoroquinolone resistance with time in *Escherichia coli* from >17,000 patients at a large county hospital as a function of culture site, age, gender, and location. BMC Infect Dis 2008;8:4.
10. Skogberg K, Lyytikäinen O, Ruutu P, Ollgren J, Nuorti JP. Increase in bloodstream infections in Finland, 1995-2002. Epidemiol Infect 2008;136(1):108-14.
11. Reacher MH, Shah A, Livermore DM, Wale MC, Graham C, Johnson AP, *et al.* Bacteraemia and antibiotic resistance of its pathogens reported in England and Wales between 1990 and 1998: trend analysis. BMJ 2000;320(7229):213-6.
12. Gransden WR, Eykyn SJ, Phillips I. Septicaemia in the newborn and elderly. J Antimicrob Chemother 1994;34(Suppl A):101-19.
13. Uslan DZ, Crane SJ, Steckelberg JM, Cockerill FR 3rd, St Sauver JL, Wilson WR, *et al.* Age- and sex-associated trends in bloodstream infection: a population-based study in Olmsted County, Minnesota. Arch Intern Med 2007;167(8):834-9.
14. Al-Hasan MN, Lahr BD, Eckel-Passow JE, Baddour LM. Epidemiology and outcome of *Klebsiella* species bloodstream infection: a population-based study. Mayo Clin Proc 2010;85(2):139-44.
15. Marschall J, Agniel D, Fraser VJ, Doherty J, Warren DK. Gram-negative bacteraemia in non-ICU patients: factors associated with inadequate antibiotic therapy and impact on outcomes. J Antimicrob Chemother 2008;61(6):1376-83.
16. Laupland KB, Gregson DB, Church DL, Ross T, Pitout JD. Incidence, risk factors and outcomes of *Escherichia coli* bloodstream infections in a large Canadian region. Clin Microbiol Infect 2008;14(11):1041-7.
17. Underwood J, Klein JL, Newsholme W. *Escherichia coli* bacteraemia: how preventable is it? J Hosp Infect 2011 ;79(4):364-5.
18. Sligl W, Taylor G, Brindley PG. Five years of nosocomial Gram-negative bacteremia in a general intensive care unit: epidemiology, antimicrobial susceptibility patterns, and outcomes. Int J Infect Dis 2006;10(4):320-5.
19. Gardiner DF, Scholand SJ, Babinchak T. Mortality and gram-negative rod bacteraemia in the intensive care unit. J Hosp Infect 2006;62(4):453-7.
20. Bereket W, Hemalatha K, Getenet B, Wondwossen T, Solomon A, Zeynudin A. Update on bacterial nosocomial infections. Eur Rev Med Pharmacol Sci 2012;16(8):1039-44.
21. Fluit AC, van der Bruggen JT, Aarestrup FM, Verhoef J, Jansen WT. Priorities for antibiotic resistance surveillance in Europe. Clin Microbiol Infect 2006;12(5):410-7.
22. Grundmann H, Klugman KP, Walsh T, Ramon-Pardo P, Sigauque B, Khan W. A framework for global surveillance of antibiotic resistance. Drug Resist Updat 2011;14(2):79-87.
23. European Centre for Disease Prevention and Control. Risk assessment on the spread of carbapenemase-producing Enterobacteriaceae (CPE) through patient transfer between healthcare facilities, with special emphasis on cross-border transfer. Stockholm: ECDC; 2011.
24. European Centre for Disease Prevention and Control. Updated risk assessment on the spread of NDM and its variants within Europe. Stockholm: ECDC; 2011.
25. European Centre for Disease Prevention and Control. Annual Epidemiological Report 2011. Reporting on 2009 surveillance data and 2010 epidemic intelligence data. Stockholm: ECDC; 2011.
26. Lynch JP 3rd, Zhanel GG. *Streptococcus pneumoniae*: epidemiology and risk factors, evolution of antimicrobial resistance, and impact of vaccines. Curr Opin Pulm Med 2010;16(3):217-25.
27. Bronzwaer SL, Cars O, Buchholz U, Mölstad S, Goettsch W, Veldhuijzen IK, *et al.* A European study on the relationship between antimicrobial use and antimicrobial resistance. Emerg Infect Dis 2002;8(3):278-82.
28. CDC. Effects of new penicillin susceptibility breakpoints for *Streptococcus pneumoniae* — United States, 2006-2007. MMWR Morb Mort Wkly Rep 2008;57(50):1353-5.
29. EUVAC-Net. Pneumococcal vaccination (PCV) overview in European countries. [Internet]. Available from http://www.euvac.net/graphics/euvac/vaccination/pcv.html
30. Johnson AP, Davies J, Guy R, Abernethy J, Sheridan E, Pearson A, *et al.* Mandatory surveillance of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteraemia in England: the first 10 years. J Antimicrob Chemother 2012;67(4):802-9.
31. Anonymous. Recent trends in antimicrobial resistance among *Streptococcus pneumoniae* and *Staphylococcus aureus* isolates: the French experience. Euro Surveill 2008;13(46). pii: 19035.
32. de Kraker ME, Davey PG, Grundmann H; BURDEN study group. Mortality and hospital stay associated with resistant *Staphylococcus aureus* and *Escherichia coli* bacteremia: estimating the burden of antibiotic resistance in Europe. PLoS Med 2011;8(10):e1001104.
33. Rampling A, Wiseman S, Davis L, Hyett AP, Walbridge AN, Payne GC, *et al.* Evidence that hospital hygiene is important in the control of methicillin-resistant *Staphylococcus aureus*. J Hosp Infect 2001;49(2):109-16.
34. Thompson DS, Workman R, Strutt M. Decline in the rates of methicillin-resistant *Staphlococcus aureus* acquisition and bacteraemia in a general intensive care unit between 1996 and 2008. J Hosp Infect 2009;71(4):314-9.
35. Vos MC, Behrendt MD, Melles DC, Mollema FP, de Groot W, Parlevliet G, *et al.* 5 years of experience implementing a methicillin-resistant *Staphylococcus aureus* search and destroy policy at the largest university medical center in the Netherlands. Infect Control Hosp Epidemiol 2009;30(10):977-84.
36. Ellington MJ, Hope R, Livermore DM, Kearns AM, Henderson K, Cookson BD, *et al.* Decline of EMRSA-16 amongst methicillin-resistant *Staphylococcus aureus* causing bacteraemias in the UK between 2001 and 2007. J Antimicrob Chemother 2010;65(3):446-8.

Annexes

Annex 1 External quality assessment (EQA) 2011

Introduction

Since 2000, EARSS/EARS-Net have organised annual external quality assessments (EQA) for antimicrobial susceptibility testing in collaboration with UK NEQAS (United Kingdom National External Quality Assessment Service). UK NEQAS is based at the Health Protection Agency in London, and is a non-profit organisation with more than 35 years of experience in external quality assessment in different countries (www.ukneqasmicro.org.uk).

The purposes of the EARS-Net EQA are:

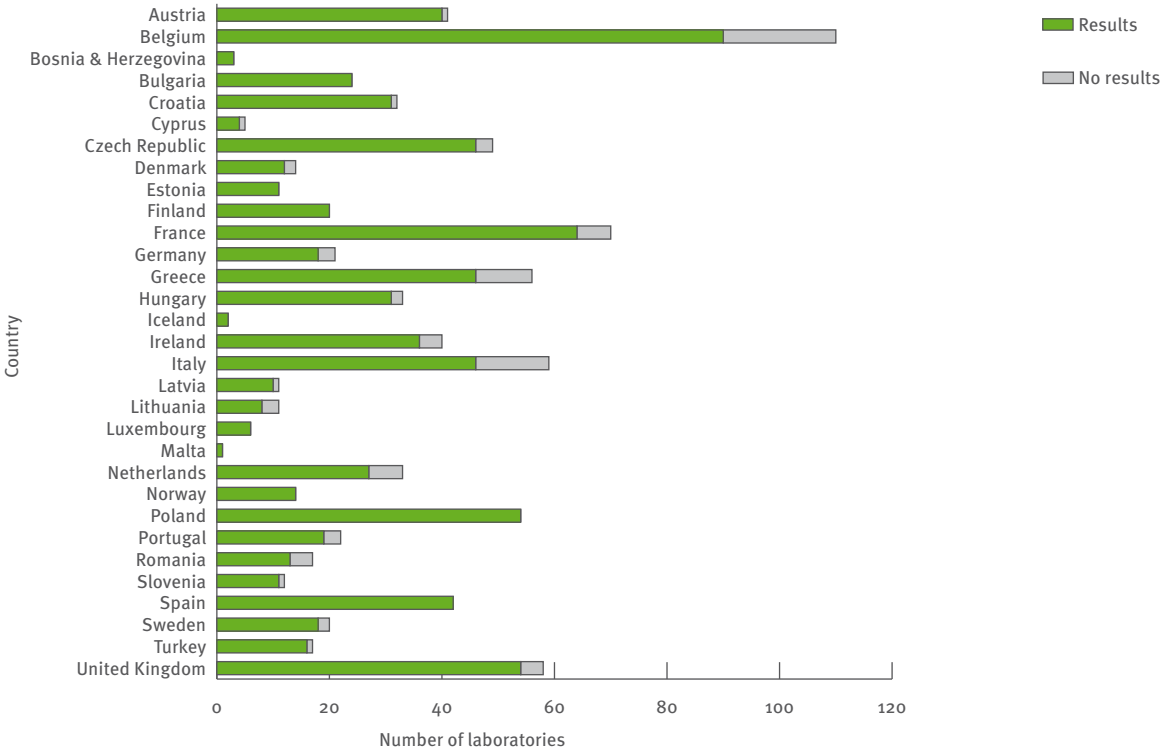
- to assess the ability of participating laboratories to identify antimicrobial resistance of clinical and public health importance;
- to determine the accuracy of susceptibility test results reported by individual laboratories;
- to estimate the overall comparability of routinely collected test results between laboratories and countries across Europe.

The strains used for the 2011 EQA were compatible with species under surveillance at ECDC, namely *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Enterococcus faecium*. The reference MICs of strains were each tested in two of three laboratories: Addenbrookes Hospital, Cambridge (UK), University Hospital of Wales, Cardiff (UK) and City Hospital, Birmingham (UK). Reference laboratories confirmed MICs and results were interpreted according to the most frequently used breakpoint criteria (EUCAST and CLSI), as indicated in the summary for each species outlined below.

Results

Six strains were distributed to 908 laboratories connected to EARS-Net. The laboratories were asked to report the identification of each organism and clinical susceptibility characterisation – susceptible, intermediate or resistant (S, I, R) – according to the guideline used. The return rate was similar to that in previous years; 817 laboratories (90%) returned reports. Figure A1.1 shows the number of participating laboratories and the number returning results per country. Participants' results were analysed and considered 'concordant' if the reported categorisation agreed with the interpretation of the MICs determined in the reference laboratories.

Figure A1.1: Number of participating laboratories returning EQA reports 2011, per country

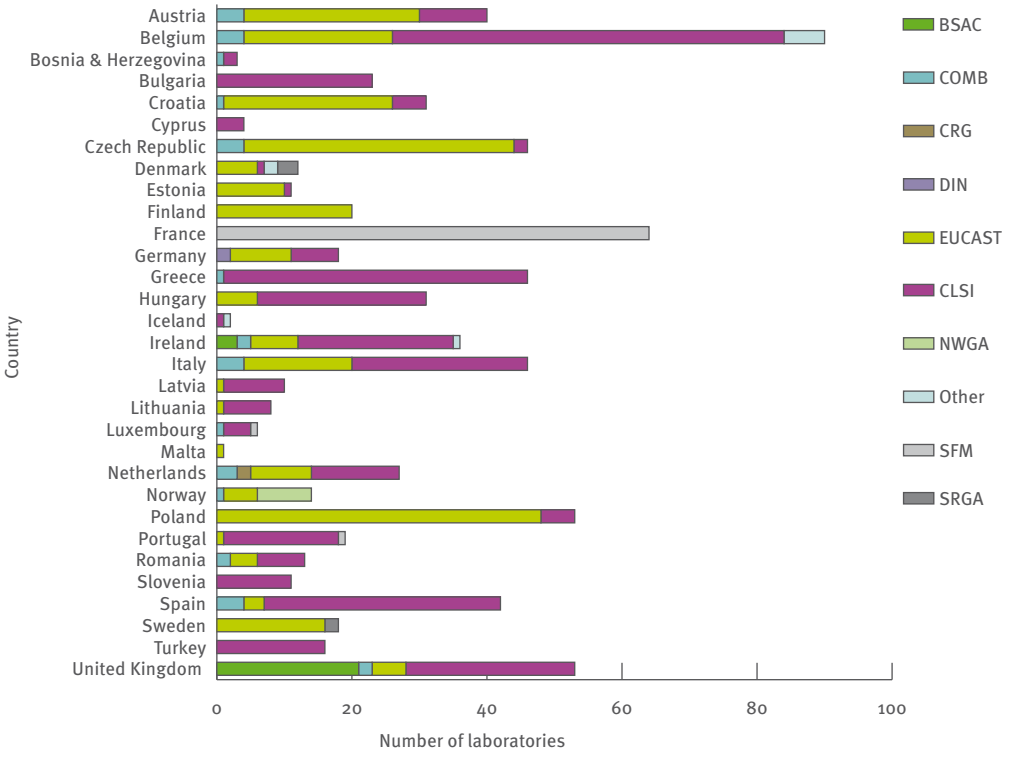


The external quality assessment exercise was open to all countries participating in EARSS in 2011.

For the determination of AST results, laboratories used automated methods (42%), disc diffusion tests (34%), or a combination of methods (16%). For species identification, 56% used automated and 44% used conventional methods. Increased use of conventional methods was to a large extent associated with identification of *S. pneumoniae* and *E. faecium*.

Forty-seven percent of laboratories used CLSI guidelines; this represented a significant reduction from the previous year when 66% used CLSI guidelines. National guidelines are commonly followed in some countries, e.g. SFM (France), BSAC (UK), SRGA (Sweden), CRG (Netherlands) and DIN (Germany). EUCAST guidelines were reported to be used by 281 (35%) laboratories, an increase of 174 laboratories since the previous year (n=107). However, the BSAC, SRGA, CRG, DIN, SFM and NWGA have been implementing EUCAST breakpoints in their national MIC breakpoint recommendations as harmonised breakpoints have been agreed, and have

Figure A1.2: Guidelines reported to be used by laboratories: number of laboratories per country, 2011



BSAC: British Society for Antimicrobial Chemotherapy; CRG: (Dutch) Commissie Richtlijnen Gevoeligheidsbepalingen; DIN: Deutsche Industrie Norm; EUCAST: European Committee on Antimicrobial Susceptibility Testing; CLSI: Clinical and Laboratory Standards institute; NWGA: Norwegian Working Group on Antimicrobials; SFM: Société Française de Microbiologie; SRGA: Swedish Reference Group for Antimicrobials. Laboratories specifying 'other' indicates did they did not use any of the specified guidelines above. Where more than one guideline was used to cover certain antimicrobial/organism combinations laboratories could select combined (COMB) as the guideline.

Table A1.1: *Escherichia coli* (0270): Minimum inhibitory concentration (MIC) and intended results reported by the reference laboratories and the overall concordance of the participating laboratories

Antibiotic agent	MIC range (mg/L) ref. lab.		Intended interpretation	
	from	to	EUCAST/CLSI	Overall concordance (%)
Amikacin	4	8	S	69
Amoxicillin	NT*		R	99
Ampicillin	≥128	≥128	R	100
Cefotaxime	≥128	≥128	R	100
Ceftazidime	16	64	R	95
Ceftriaxone	≥128	≥128	R	100
Ciprofloxacin	64	≥128	R	100
Gentamicin	32	≥128	R	100
Imipenem	0.06	0.12	S	99
Meropenem	0.016	0.03	S	100
Piperacillin*			R	99
Piperacillin–tazobactam	8	16	S/I	56
Tobramycin	32	64	R	100
ESBL**			Positive	100

* Not tested, reference MICs were participants' results.
** ESBL: Extended-spectrum beta-lactamase
S: susceptible; R: resistant; I: intermediate.

adjusted the interpretation of their disc diffusion methods accordingly. Therefore, a combined total of some 48% of laboratories used EUCAST breakpoints. Figure A1.2 shows the adherence to (inter)national guidelines by number of laboratories per country.

Specimen 0270 *Escherichia coli*

This specimen consisted of an *Escherichia coli* with a CTX-M-15 ESBL. There were no problems detecting resistance to cephalosporins or in identifying that the organism was an ESBL-producer.

Reference MICs of piperacillin–tazobactam were 8–16 mg/L (fixed concentration of 4 mg/L tazobactam), so susceptibility was borderline and interpreted as susceptible or intermediate by EUCAST breakpoints and susceptible by CLSI breakpoints. Results of participants were also variable, with 32.7% reporting piperacillin–tazobactam-susceptible, 23.7% intermediate and a higher than expected rate (43.6%) reporting resistant. The percentage of participants reporting susceptible or intermediate was similar for those using EUCAST-based breakpoints (57% of 356 laboratories) and those using CLSI breakpoints (59.2% of 341 laboratories). Those using automated methods were more likely to report resistance (63.1% of 225 participants) than those using MIC methods (55.3% of 103), multiple methods (44.6% of 94) or disc diffusion methods (24.5% of 310). Current guidelines from both EUCAST and CLSI recommend reporting β-lactamase inhibitor combinations 'as found' in routine tests. Despite this, for participants where data are available, some laboratories edited susceptible test results to intermediate or resistant, or edited intermediate test results to resistant (in total around 34% of participants using disc diffusion methods, 24% using MIC methods and 9% using automated methods).

Reference MICs of amikacin were 4–8 mg/L, which is slightly raised compared with typical susceptible isolates, but interpreted as susceptible by both EUCAST and CLSI breakpoints. The isolate was reported susceptible by 61.8% participants, intermediate by 31.6% and resistant by 6.6% (Table A1.1).

Specimen 0271 *Klebsiella pneumoniae*

This specimen consisted of a *Klebsiella pneumoniae* which produces both a KPC carbapenemase and an SHV-12 ESBL.

Although the organism is a carbapenemase producer, reference carbapenem MICs by the ISO broth microdilution method were low, 0.5–1 mg/L for imipenem, which would be reported susceptible by both EUCAST and CLSI, and 4 mg/L for meropenem, which would be reported intermediate by EUCAST breakpoints and resistant by CLSI breakpoints. Most participants, however, reported reduced susceptibility to imipenem (6.3% susceptible, 19.3% intermediate and 74.4% resistant) and to meropenem (6.4% susceptible, 9.5% intermediate and 84.1% resistant). MICs reported by participants were very variable, from 0.12 to 256 mg/L with a mode of 8 mg/L for imipenem and 0.5–128 mg/L with a mode of 2 mg/L for meropenem. The reason for the highly variable carbapenem MICs is unclear, but repeat MICs by the ISO broth microdilution method in one of the reference laboratories after the distribution were 16 mg/L for imipenem and 32 mg/L for meropenem, suggesting that there may have been variation in the strain, which would inevitably result in variable reporting.

Detection of ESBLs may be required for epidemiological purposes and the presence of a carbapenemase in addition to an ESBL in this isolate makes detection of the SHV-12 ESBL problematic. With this isolate, clavulanic acid synergy tests were difficult to interpret as there was only slight reduction in third- generation cephalosporin MICs, depending on the cephalosporin tested, and resistance mediated by carbapenemases can also be marginally affected by clavulanate. Among participants, 54.2% reported the presence of an ESBL. Reporting of susceptibility to β-lactam agents other than carbapenems was not an issue as reference MICs were uniformly high.

Table A1.2: *Klebsiella pneumoniae* (0271): Minimum inhibitory concentration (MIC) and intended results reported by the reference laboratories and the overall concordance of the participating laboratories

Antibiotic agent	MIC range (mg/L) ref. lab.		Intended interpretation	
	from	to	EUCAST/CLSI	Overall concordance (%)
Amikacin	16	16	S/I/R	100
Amoxicillin	≥128		I/R	100
Ampicillin	≥128	≥128	R	100
Cefotaxime	≥128	≥128	R	100
Ceftazidime	≥128	≥128	R	100
Ceftriaxone	≥128	≥128	R	100
Ciprofloxacin	≥128	≥128	R	100
Gentamicin	1	1	S	87
Imipenem	1	1	S	10
Meropenem	4	4	I/R	94
Piperacillin*			R	100
Piperacillin–tazobactam	≥128	≥128	R	100
Tobramycin	≥128	≥128	R	99
ESBL**			Positive	57

* Not tested, reference MICs were participants' results.
** ESBL: Extended-spectrum beta-lactamase
S: susceptible; R: resistant; I: intermediate.

Aminoglycoside susceptibility was typical of an organism producing AAC(6')I in that it was resistant to tobramycin (MIC ≥128 mg/L), susceptible to gentamicin (MIC 1 mg/L) and borderline to amikacin (MIC 16 mg/L; intermediate by EUCAST breakpoints and susceptible by CLSI breakpoints). EUCAST expert rules note that acquired AAC(6')I may not confer phenotypic resistance to amikacin despite modification of amikacin, and that such organisms should be reported intermediate even if they appear susceptible. There were no significant problems with tobramycin and only 1.2% of participants reported the organism susceptible to amikacin, the majority (89.8%) reporting resistance. For gentamicin, 88.7% of participants reported the isolate as susceptible, 8.1% as intermediate and 3.2% as resistant (Table A1.2).

Specimen 0272 *Streptococcus pneumoniae*

This specimen consisted of a *Streptococcus pneumoniae* with reduced susceptibility to penicillin (MIC 0.5 mg/L).

For *S. pneumoniae* with no mechanism of resistance to penicillin, MICs are ≤0.06 mg/L. However, the interpretation of susceptibility to penicillin depends on whether the isolate is from a patient with pneumonia, meningitis or other infections. Strains with intermediate susceptibility (EUCAST MIC 0.06–2 mg/L, CLSI MIC 0.06–4 mg/L) are treatable with the high doses of penicillin, ampicillin or amoxicillin routinely used to treat pneumonia. Hence such strains may be reported susceptible in this situation. Patients with meningitis caused by strains with intermediate susceptibility to penicillin are unlikely to respond to therapy, and hence such strains should be reported as resistant in this situation. Participants were asked to give the interpretations that would be reported if the isolate was from a case of pneumonia and if the isolate was from a case of meningitis.

Overall, 90.8% participants reported resistance in the oxacillin screening test for penicillin resistance. An additional 4.6% reported oxacillin intermediate although there is no intermediate category for the oxacillin screening test. There were no problems in detecting reduced susceptibility to oxacillin in reference tests by the EUCAST and CLSI methods.

The participants' results for penicillin without a site of infection cannot be interpreted because guideline breakpoints relate to the site of infection. However, for penicillin without a site of infection 69.8% designated the isolate as being of intermediate susceptibility to penicillin, with a further 6.7% reporting the isolate resistant and 23.5% susceptible. Susceptibility reported to clinicians indicates variable practice in that some participants do not interpret test results to suit the clinical situation, as only 86.4% reported the isolate resistant if the isolate was from a case of meningitis and only 76.1%

Table A1.3: *Streptococcus pneumoniae* (0272): Minimum inhibitory concentration (MIC) and intended results reported by the reference laboratories and the overall concordance of the participating laboratories

Antibiotic agent	MIC range (mg/L) ref. lab.		Intended interpretation	
	from	to	EUCAST/CLSI	Overall concordance (%)
Cefotaxime				
Meningitis			S	-
Pneumonia	0.25	0.25	S/-	95
Other			S/-	99
Non-meningitis			-	-
Ceftriaxone				99
Meningitis			S	-
Pneumonia	0.25	0.25	S/-	96
Other			S/-	99
Non-meningitis			-/S	-
Ciprofloxacin	0.5	1	I/no interpretation	35
Clindamycin	0.12	0.12	S	98
Erythromycin	32	› 128	R	96
Penicillin				
Meningitis			R	-
Pneumonia	0.5	0.5	S/-	86
Other			I/-	73
Non-meningitis			-/S	-

S: susceptible; R: resistant; I: intermediate.

Table A1.4: *Enterococcus faecium* (0273): Minimum inhibitory concentration (MIC) and intended results reported by the reference laboratories and the overall concordance of the participating laboratories

Antibiotic agent	MIC range (mg/L) ref. lab.		Intended interpretation	
	from	to	EUCAST/CLSI	Overall concordance (%)
Amoxicillin	NT*		R	89
Ampicillin	16	32	R	98
High-level gentamicin	4	4	S (not high-level resistance)	74
Teicoplanin	0.5	1	S	98
Vancomycin	8	16	R/I	79

* Not tested, result inferred from ampicillin result.
S: susceptible; R: resistant; I: intermediate.

reported susceptible if the isolate was from a case of pneumonia. Significant numbers of participants interpreted the isolate as intermediate in susceptibility to penicillin irrespective of whether the isolate was from meningitis (8.1% reported intermediate) or from pneumonia (20.8% reported intermediate). These differences will partly relate to national differences in reporting practices.

Resistance to cefotaxime and ceftriaxone is rare in *S. pneumoniae* and a high percentage of participants reported the isolate susceptible to these agents whatever the source of the infection.

Ciprofloxacin is not the fluoroquinolone of choice for treatment of infections with *S. pneumoniae*. EUCAST categorise wild-type isolates as intermediate and CLSI do not include breakpoints in current tables. Only around half the participants tested this organism against ciprofloxacin and, contrary to guidelines, 55.4% of those testing ciprofloxacin reported the isolate susceptible (Table A1.3).

Specimen 0273 *Enterococcus faecium*

This specimen consisted of an *Enterococcus faecium* with vanB-mediated resistance to vancomycin.

Vancomycin MICs can be low for VanB strains, as in this case (MICs 8–16 mg/L), and the isolate would be interpreted as resistant by EUCAST breakpoints but intermediate by CLSI breakpoints. The borderline susceptibility makes detection of reduced susceptibility more difficult, particularly with disc diffusion methods where the difference in zone diameter between susceptible and resistant isolates may be small and resistance may be seen only as small colonies inside zone edges, or 'fuzzy' zone edges after 24 hours incubation, in contrast with the sharp zone edges seen with susceptible isolates. Reduced susceptibility to vancomycin was detected by only 92% of participants (8.6% intermediate, 83.4% resistant).

Gentamicin mono-therapy is ineffective against enterococci. There is, however, synergism between gentamicin and β-lactam agents against enterococci without mechanisms conferring high-level gentamicin resistance (usually production of the bi-functional enzyme APH(2'')/AAC(6')). Overall, 24.7% of participants incorrectly reported this isolate as high-level gentamicin-resistant. Previously, similar errors have been related to the erroneous use of lower content gentamicin discs than specified in disc diffusion method guidelines; this may also explain the incorrect results for 2011.

This organism is resistant to ampicillin and amoxicillin with EUCAST breakpoints. CLSI specifies that susceptibility of enterococci to amoxicillin should be inferred from the ampicillin susceptibility, so the organism

Table A1.5: *Pseudomonas aeruginosa* (0274): Minimum inhibitory concentration (MIC) and intended results reported by the reference laboratories and the overall concordance of the participating laboratories

Antibiotic agent	MIC range (mg/L) ref. lab.		Intended interpretation	
	from	to	EUCAST/CLSI	Overall concordance (%)
Amikacin	1	4	S	94
Ceftazidime	1	2	S	98
Ciprofloxacin	0.12	0.5	S	99
Gentamicin	16	≥128	R*	99
Imipenem	1	2	S	99
Meropenem	0,5	2	S	98
Piperacillin–tazobactam	4	8	S	83
Tobramycin	0.5	1	S	99

* Reference MICs covered the range of susceptible to resistant by both EUCAST and CLSI.
S: susceptible; R: resistant; I: intermediate.

Table A1.6: *Staphylococcus aureus* (0275): Minimum inhibitory concentration (MIC) and intended results reported by the reference laboratories and the overall concordance of the participating laboratories

Antibiotic agent	MIC range (mg/L) ref. lab.		Intended interpretation	
	from	to	EUCAST/CLSI	Overall concordance (%)
Cefoxitin	8	16	R	95
Ciprofloxacin	0.5	0.5	S	98
Clindamycin	0.12	0.12	dissociated resistance	75
Erythromycin	8	64	R	92
Fusidic acid	0.06	0.12	S	99
Gentamicin	0.25	0.5	S/no interpretation	98
Meticillin	NT*		R	99
Oxacillin	8	32	R	96
Penicillin	1	4	R	100
Rifampicin	0.004	0.008	S	100
Teicoplanin	1	1	S	100
Tetracycline	64	64	R	98
Vancomycin	1	2	S	99

* Not tested, result inferred from oxacillin and cefoxitin results.
S: susceptible; R: resistant; I: intermediate.

should also be reported resistant to ampicillin and amoxicillin by CLSI guidelines. Overall, 98.8% of participants reported resistance to ampicillin. Only one third of participants reported susceptibility results for amoxicillin and of these only 84.2% reported resistance, with 7.9% reporting intermediate and another 7.9% reporting susceptible (Table A1.4).

Specimen 0274 *Pseudomonas aeruginosa*

This specimen consisted of a *Pseudomonas aeruginosa* resistant to gentamicin and susceptible to other reference agents tested.

Some laboratories experienced problems with piperacillin–tazobactam testing in that overall 6.2% of participants reported the isolate intermediate and 5.7% resistant. The reason for the problems is not obvious as the isolate was clearly susceptible in reference tests by both MIC and disc diffusion methods (Table A1.5).

Specimen 0275 *Staphylococcus aureus*

This specimen consisted of a meticillin-resistant *Staphylococcus aureus* with dissociated resistance to clindamycin.

Testing for meticillin resistance still causes problems in some laboratories as only 95.2% reported resistance to cefoxitin and 95% to oxacillin.

As seen with previous distributions of organisms with dissociated resistance, there were significant discrepancies in reporting susceptibility to clindamycin, with 74.2% reporting resistant, 1.8% intermediate and 24.0% susceptible. In staphylococci, most resistance to macrolide, lincosamide and streptogramin type B (MLS_B) antimicrobials is mediated by the *erm* genes and is induced by erythromycin, clarithromycin and azithromycin, but not by clindamycin (dissociated resistance or MLS_B-inducible resistance). Hence inducible strains are resistant to erythromycin but not to clindamycin in susceptibility tests. Strains with MLS_B-constitutive resistance are resistant to both agents.

There has been debate about whether staphylococci with inducible resistance (erythromycin-resistant, clindamycin-susceptible) should be reported resistant as inducible strains segregate clindamycin-resistant mutants, which may be selected during therapy. EUCAST expert rules indicate that such strains should either be reported as resistant to clindamycin or reported as susceptible with a warning of possible clinical failure during treatment with clindamycin due to selection of constitutively resistant mutants. EUCAST also states that the use of clindamycin is best avoided for severe infections caused by isolates with dissociated resistance. CLSI suggest that such strains should be reported resistant but that a comment may be added that clindamycin may still be effective in some patients. Inducible clindamycin resistance is detected in disc diffusion tests with a clindamycin disc placed adjacent to an erythromycin disc; strains with inducible resistance show flattening of the clindamycin zone adjacent to the erythromycin disc (Table A1.6).

Conclusions

The response to the 2011 EARS-Net EQA was very good with a high return rate and very few late responders. Performance was generally very good and consistent with that seen in previous EQA. Problems, where experienced, were related to borderline susceptibility and when guidelines revealed remaining discrepancies in routine susceptibility testing.

ECDC would like to thank UK NEQAS, the reference laboratories, the members of the EARS-Net Coordination Group and the country coordinators for the swift distribution of the strains, and all the participating laboratories for their efforts and timely response to the assessment.

Annex 2 EARS-Net laboratory/hospital denominator data 2011

Introduction

For correct interpretation of the EARS-Net data on antimicrobial resistance, accurate background information is important. Therefore, laboratory and hospital denominator data are collected and presented in this Annex.

Methods

Questionnaires (Microsoft Excel files) were sent to the EARS-Net contact points in May 2012. The contact points distributed the questionnaires to the participating laboratories and hospitals in their country. Information was collected on the total number of blood culture sets processed in the laboratories, and the number of hospital beds for each participating hospital, the type of hospital, the bed occupancy and the number of admissions. The national data managers received the completed questionnaires, compiled them and produced the final format suitable for uploading to The European Surveillance System (TESSy). Laboratories were defined as reporting denominator data if they provided the number of blood culture sets performed for one or more hospitals. Hospitals were defined as reporting denominator data if they provided the number of beds.

Organisation of health care systems and affiliation between laboratories and hospitals differs considerably between countries, which might influence data comparability. For countries submitting denominator data for a small percentage of hospitals and/or laboratories contributing data to EARS-Net, the reported figures might not be representative for the overall country profile.

Participation

Sixteen of the 29 countries reporting AMR data also returned hospital and laboratory denominator data referring to 2011, while for eight countries, hospital and laboratory denominator data referring to 2010 were available and included in the analysis. In total, 1012 (70 %) of the 1445 hospitals and 477 (61 %) of the 784 laboratories reporting AST results for the 24 countries, also provided denominator data (Figures A2.1, A2.2 and Tables A2.1–A2.3). Some denominator data for laboratories and hospitals not reporting AMR data, or reporting zero cases, have been included in Figure A2.1, but were not included in other parts of the analysis.

Population coverage

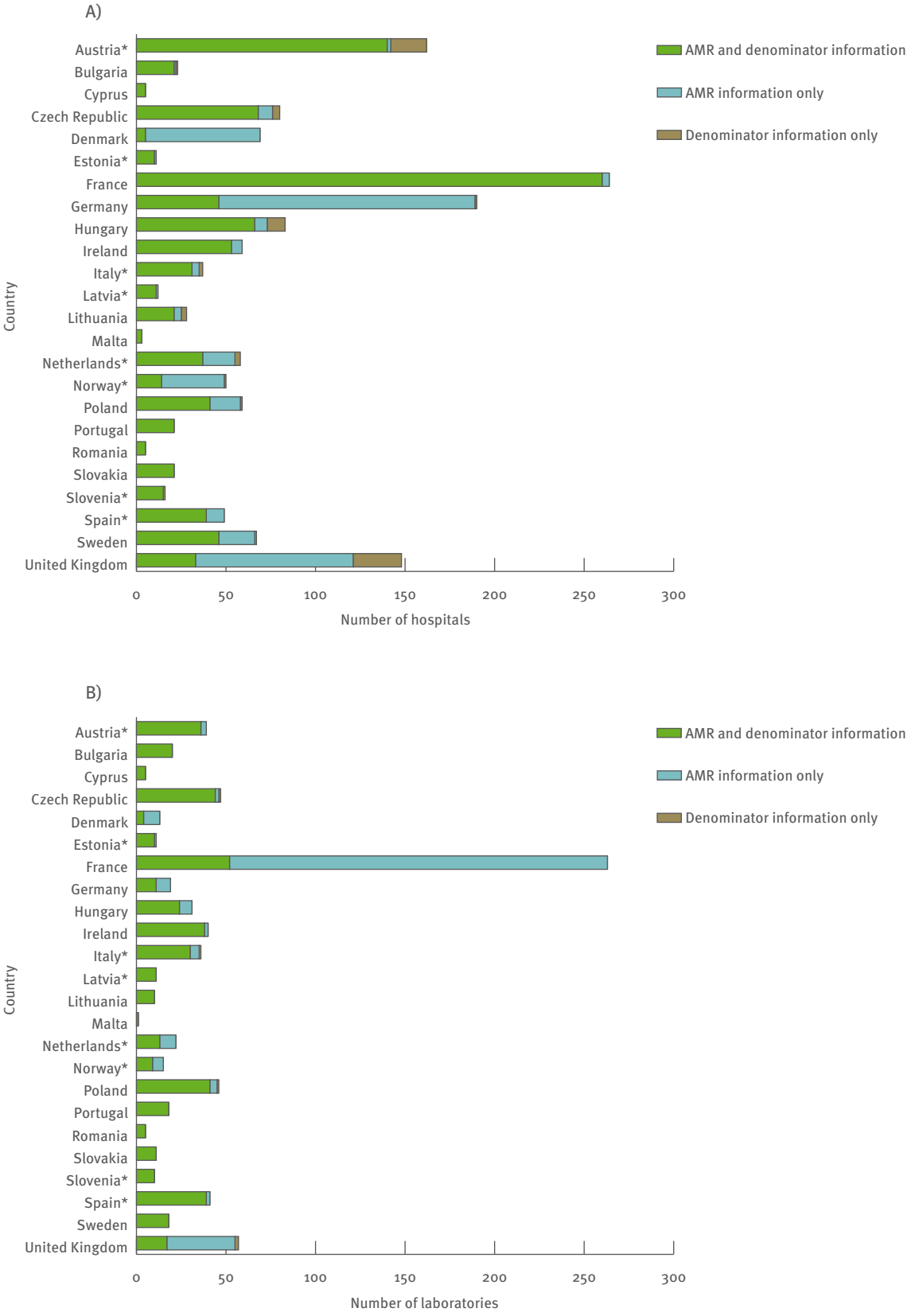
Data on population coverage for AMR data at country level are not reported because of the inherent limitations of these data. Not all laboratories/hospitals reporting AST data also provide denominator data, and this would introduce bias into the calculation of country population coverage since only laboratories/hospitals

Table A2.1: Hospital denominator data for 2010 or 2011 (using latest available data)

Country	Hospitals reporting (denominator/AMR data)	Total number of beds	Proportion of ICU beds (%)	Annual occupancy rate (%)	Median length of stay (days)	IQR length of stay (days)
Austria*	(140/142)	54743	5	67	4.7	4.1-5.4
Bulgaria	(21/22)	9474	8	76	6.1	5.4-6.6
Cyprus	(5/5)	1316	10	77	5.3	5.1-5.4
Czech Republic	(68/76)	38911	11	70	7.2	6.1-8.3
Denmark	(5/69)	3254		82	3.2	2.8-3.6
Estonia*	(10/11)	4472	4	76	6.3	5.1-7.1
France	(260/264)	156586	5	81	7.4	6.2-8.8
Germany	(46/189)	18296	7	76	6.9	6.5-7.9
Hungary	(66/73)	51240	2	74	8.5	7.1-9.4
Ireland	(53/59)	12265	3	87	5.5	4.6-6.8
Italy*	(31/35)	10249		83		∴
Latvia*	(11/12)	5135	3	71	6.1	4.1-6.8
Lithuania	(21/25)	10734	4	74	7.1	6.0-8.8
Malta	(3/3)	1157	6	87	5.3	4.8-45.0
Netherlands*	(37/55)	14886		67	5.2	4.9-5.6
Norway*	(14/49)	4347	5	84	4.4	4.0-4.7
Poland	(41/58)	20432	2	71	5.0	4.0-6.0
Portugal	(21/21)	9680	6	79	7.1	5.7-7.9
Romania	(5/5)	2964	6	85	6.2	5.7-6.4
Slovakia	(21/21)	11354	9	70	6.9	6.2-7.9
Slovenia*	(15/15)	7265	6	71	5.8	4.8-6.5
Spain*	(39/49)	24571	4	79		∴
Sweden	(46/66)	15882	4	91	4.7	4.1-5.2
United Kingdom	(33/121)	11561	2	79	4.4	2.9-7.7

* Data from 2010.

Figure A2.1: Number of hospitals (A) and laboratories (B) reporting AMR and/or denominator data in 2010 or 2011 (using latest available data)



* Denominator data from 2010.

reporting denominator data can be included. Secondly, laboratories and hospitals cluster in big cities and, for this reason, some of the catchment areas overlap. This could lead to double counts, which would artificially increase the estimated coverage.

Hospital denominator information

The total number of hospital beds for hospitals reporting both AMR and denominator data in different countries ranged from 1157 in Malta to 156586 in France, reflecting the size of the country as well as the rate of participation to EARS-Net and the rate of response to the questionnaires.

The percentage of ICU beds over total hospital beds shows wide variation by country, ranging from 2 % in Hungary, Poland and the United Kingdom to 11 % in the Czech Republic. The overall median length of stay in hospital was 5.9 days with the lowest median in Denmark (3.2 days) and the highest in Hungary (8.5 days). The annual occupancy rate was 75 % or higher in 15 out of 24 countries (Table A2.1).

Hospital characteristics

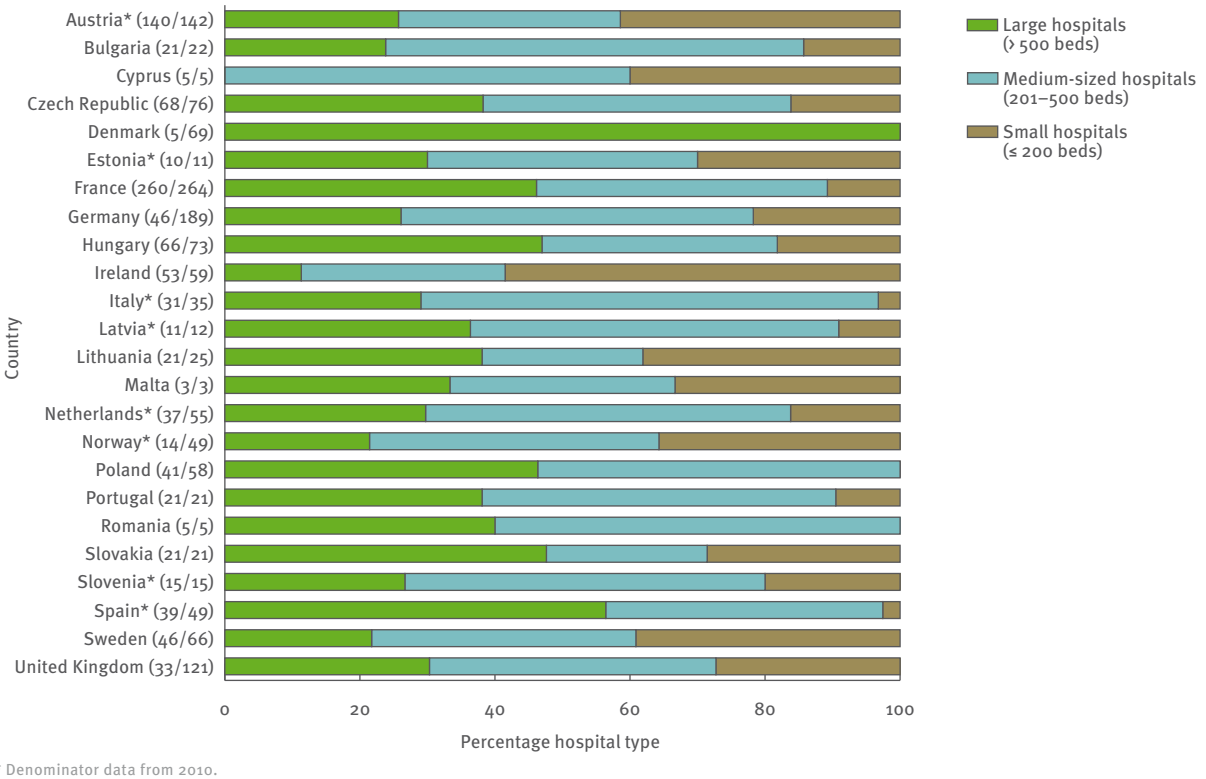
Both the size of a hospital and the level of specialisation may influence the occurrence of antimicrobial resistance in the hospital. As can be seen from Table A2.2 and Figure A2.2, the distribution of size and specialisation level of hospitals varied considerably between the reporting countries. This does not necessarily reflect different distributions of the origin of EARS-Net blood cultures per country, as not all hospitals contribute evenly to the EARS-Net database. On the other hand, this diversity can indicate differences in case-mix, which may confound comparison of AMR results between countries.

The type of hospital and the size of hospital are not always linked and it is not rare, especially in smaller countries, that university hospitals have fewer than 500 beds.

Laboratory denominator information

In 2010/2011 (latest available data), the number of blood culture sets processed in the EARS-Net laboratories responding to the questionnaire was 3278850. The median culturing frequency was 28.3 blood culture sets per 1000 patient days. The highest rate was reported by Italy (91.3) and the lowest by Lithuania (5.5). For the majority of the reporting countries, there are only minor changes in the number of blood culture sets taken per 1000 patient days (Table A2.3) when comparing 2009/2010 (latest available data) data with 2010/2011 (latest available data). The highest total number of blood culture sets was reported by France (881270) followed by Sweden (352450).

Figure A2.2: Percentage of small, medium and large hospitals per country, based on the number of beds, for all hospitals reporting both antimicrobial resistance data and denominator data in 2010 or 2011 (using latest available data)



* Denominator data from 2010.

Table A2.2: Hospital characteristics for 2010 or 2011 (using latest available data)

Country	Hospitals reporting (denominator/AMR data)	Proportion of hospitals by level of care (%)				
		Tertiary level	Secondary level	Primary level	Other	Unknown
Austria*	(140/142)	8	24	39	29	0
Bulgaria	(21/22)	52	33	5	10	0
Cyprus	(5/5)	20	20	40	20	0
Czech Republic	(68/76)	34	34	29	3	0
Denmark	(5/69)	40	40	0	0	20
Estonia*	(10/11)	0	50	20	30	0
France	(260/264)	22	77	0	0	1
Germany	(46/189)	33	30	28	7	0
Hungary	(66/73)	50	26	14	11	0
Ireland	(53/59)	17	55	11	17	0
Italy*	(31/35)	16	16	0	0	0
Latvia*	(11/12)	45	18	9	27	0
Lithuania	(21/25)	48	38	10	5	0
Malta	(3/3)	33	33	0	33	0
Netherlands*	(37/55)	8	73	19	0	0
Norway*	(14/49)	36	36	29	0	0
Poland	(41/58)	29	66	0	5	0
Portugal	(21/21)	57	33	5	5	0
Romania	(5/5)	80	20	0	0	0
Slovakia	(21/21)	67	0	5	29	0
Slovenia*	(15/15)	13	47	20	13	7
Spain*	(39/49)	56	38	5	0	0
Sweden	(46/66)	17	39	43	0	0
United Kingdom	(33/121)	27	27	24	6	9

* Data from 2010.
Primary level or district hospital = has few specialties, limited laboratory services; bed capacity ranges from 30 to 200 beds. Secondary level, or provincial hospital = highly differentiated by function with five to 10 clinical specialties; bed capacity ranging from 200 to 800 beds. Tertiary level or central/regional hospital = highly specialised staff and technical equipment; clinical services are highly differentiated by function; may have teaching activities; bed capacity ranges from 300 to 1500 beds. Other = hospitals for a specific patient population, like a military hospital, or hospitals with any single specialty, like a burns unit.
Unknown = not available.

Table A2.3: Laboratory denominator information for 2010 or 2011 (using latest available data)

Country	Laboratories reporting (denominator/AMR data)	Number of hospitals	Total number of blood culture sets	Number of blood culture sets per 1000 patient days
Austria*	(36/39)	127	178672	14.1
Bulgaria	(20/20)	21	19642	7.5
Cyprus	(5/5)	5	13513	36.5
Czech Republic	(44/46)	68	144615	14.5
Denmark	(4/13)	4	79269	81
Estonia*	(10/11)	11	20593	16.6
France	(52/263)	52	881270	61
Germany	(11/19)	37	69259	16.5
Hungary	(24/31)	54	87980	7.8
Ireland	(38/40)	53	180995	46.7
Italy*	(30/35)	30	209974	91.3
Latvia*	(11/11)	11	12726	9.6
Lithuania	(10/10)	21	15920	5.5
Malta	(1/1)	3	8796	24
Netherlands*	(13/22)	28	99034	38.3
Norway*	(9/15)	14	62532	46.7
Poland	(41/45)	41	125330	23.4
Portugal	(18/18)	21	122744	43.8
Romania	(5/5)	5	27252	29.5
Slovakia	(11/11)	21	60922	20.9
Slovenia*	(10/10)	14	50480	27
Spain*	(39/41)	39	308872	43.4
Sweden	(18/18)	46	352450	67.1
United Kingdom	(17/55)	26	146763	48.1

* Data from 2010.

Discussion and conclusions

In summary, the situation for most countries as assessed from denominator data reported to EARS-Net in 2011 appears stable and similar to 2010. This indicates that based on EARS-Net data the comparison of resistance percentages over time remains valid.

The BSIs ascertainment is strongly linked to the blood culture rate. Therefore, the wide range in blood culture rates observed in the countries providing denominator data has implications for inter-country comparisons of both the incidence rate of infections, which could be underestimated in some countries, and of the percentage of resistance. In particular, the percentage of resistance could be overestimated if blood cultures are not systematically performed before starting empiric therapy and if blood cultures are more likely to be performed in patients not responding to initial empiric treatment.

For future improvement of the denominator data collection and analysis, a further increase in the number of countries reporting denominator data, as well as an increased number of hospital and laboratories participating within countries, would be desirable. Furthermore, an improved estimation of the coverage of the EARS-Net surveillance, e.g. by using estimations done at the national level based on knowledge of the country-specific situation, would also be desirable.

Country summary sheets

Explanation to the country summary sheets

General information about EARS-Net participating laboratories and hospitals

Table 1 gives the number of laboratories and isolates reported by year and by pathogen under EARSS/EARS-Net surveillance for the period 2003–2011.

Antibiotic resistance 2003–2011

Table 2 provides information on the proportion of invasive bacterial isolates non-susceptible (I+R) or resistant (R) to the antibiotics or antibiotic classes mentioned in the EARSS/EARS-Net protocols. When interpreting the results in Table 2, always check the number of isolates provided in Table 1.

Demographic characteristics

Table 3 gives the proportional distribution of the isolates reported by source, gender, age, and hospital department, and the percentage of resistance within the different groups, for the period 2010–2011.

The abbreviations used in this table stand for:

PNSP = penicillin-non-susceptible *S. pneumoniae*;

MRSA = meticillin-resistant *S. aureus*;

FREC = fluoroquinolone-resistant *E. coli*;

VRE = vancomycin-resistant *E. faecalis* or *E. faecium*;

3GCRKP = third-generation cephalosporin-resistant *K. pneumoniae*; and

CRPA = carbapenem-resistant *P. aeruginosa*.

If the number of isolates in a certain category accounts for less than 0.5% of the total number of isolates, the % total is set at <1.

PNSP at laboratory level/MRSA, FREC and 3GCRKP at hospital level

Figures 1, 2, 3 and 4 show the local variation in the percentage of PNSP by laboratory and of MRSA, FREC and 3GCRKP by hospital. These figures are based on data from 2010 and 2011, only including the laboratories and hospitals that reported at least five isolates in these two years. The total number of laboratories or hospitals, the minimum, maximum, median, first and third quartile of the proportion of resistance is displayed in a box in the figures.

Austria

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	20	163	20	871	21	985	19	327	-	-	-	-
2004	28	257	30	1453	31	1862	28	604	-	-	-	-
2005	31	298	32	1481	33	2058	30	568	7	89	8	77
2006	32	293	33	1640	33	2483	33	699	30	434	31	405
2007	35	322	34	1577	34	2545	33	688	33	445	33	411
2008	38	380	38	1899	38	2985	38	864	38	583	38	510
2009	38	379	38	1794	38	2625	36	825	37	622	36	525
2010	35	375	39	1840	39	2937	39	944	39	722	39	504
2011	39	438	40	1982	40	3174	40	894	40	799	40	544

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	1	1	<1	<1	2	<1	3	2	2
Penicillin RI	9	5	5	5	5	5	5	4	3
Macrolides RI	13	13	15	13	13	12	14	11	12
Staphylococcus aureus									
Oxacillin/Meticillin R	15	14	14	9	11	8	6	7	7
Escherichia coli									
Aminopenicilins R	41	46	49	53	53	50	49	51	50
Aminoglycosides R	5	6	6	8	8	7	6	6	7
Fluoroquinolones R	14	17	19	22	26	23	20	21	22
Third-gen. cephalosporins R	2	3	4	7	9	7	8	7	9
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	1	<1	1	2	2	2	1	2	<1
HL Gentamicin R	33	23	29	29	30	21	31	32	31
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	85	85	85	89	82	91	88	92	91
HL Gentamicin R	22	22	30	21	28	19	31	42	49
Vancomycin R	<1	<1	1	<1	2	2	4	4	5
Klebsiella pneumoniae									
Aminoglycosides R	-	-	3	5	5	6	4	6	7
Fluoroquinolones R	-	-	11	8	13	12	8	18	17
Third-gen. cephalosporins R	-	-	6	6	8	8	8	13	13
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	13	8	6	8	6	9	14
Ceftazidime R	-	-	7	9	5	6	6	8	11
Carbapenems R	-	-	10	15	12	11	9	14	14
Aminoglycosides R	-	-	6	9	9	8	8	10	13
Fluoroquinolones R	-	-	14	15	15	12	13	16	19

Note: National data analysis allows for a more accurate validation. Due to differences in the validation algorithms used by EARS-Net and Austria, there are small discrepancies in data presented by EARS-Net.

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	97	3	100	7	100	22	100	1	100	4	100	13	100	14
CSF	3	4	-	-	<1	75	-	-	-	-	<1	43	0	0
Gender														
Male	55	3	57	7	43	26	62	1	62	4	56	15	57	13
Female	45	4	42	7	57	18	37	0	38	5	43	10	42	15
Unknown	-	-	1	8	1	36	1	0	1	0	1	19	<1	40
Age (years)														
0–4	5	3	2	5	1	6	2	0	1	0	2	36	1	0
5–19	2	0	1	7	1	15	0	0	0	0	1	21	1	29
20–64	40	3	33	6	25	22	30	0	36	6	31	14	32	18
65 and over	53	4	64	8	73	22	67	1	62	4	67	12	67	12
Hospital department														
ICU	15	8	10	13	8	25	14	3	27	6	13	20	14	20
Internal med.	56	3	50	6	55	20	42	0	38	2	44	11	39	11
Surgery	2	0	9	11	7	19	11	1	9	3	9	17	9	11
Other	23	2	26	6	26	24	27	0	23	5	29	13	34	16
Unknown	4	7	5	6	4	22	7	0	3	14	5	9	5	11

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Austria

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

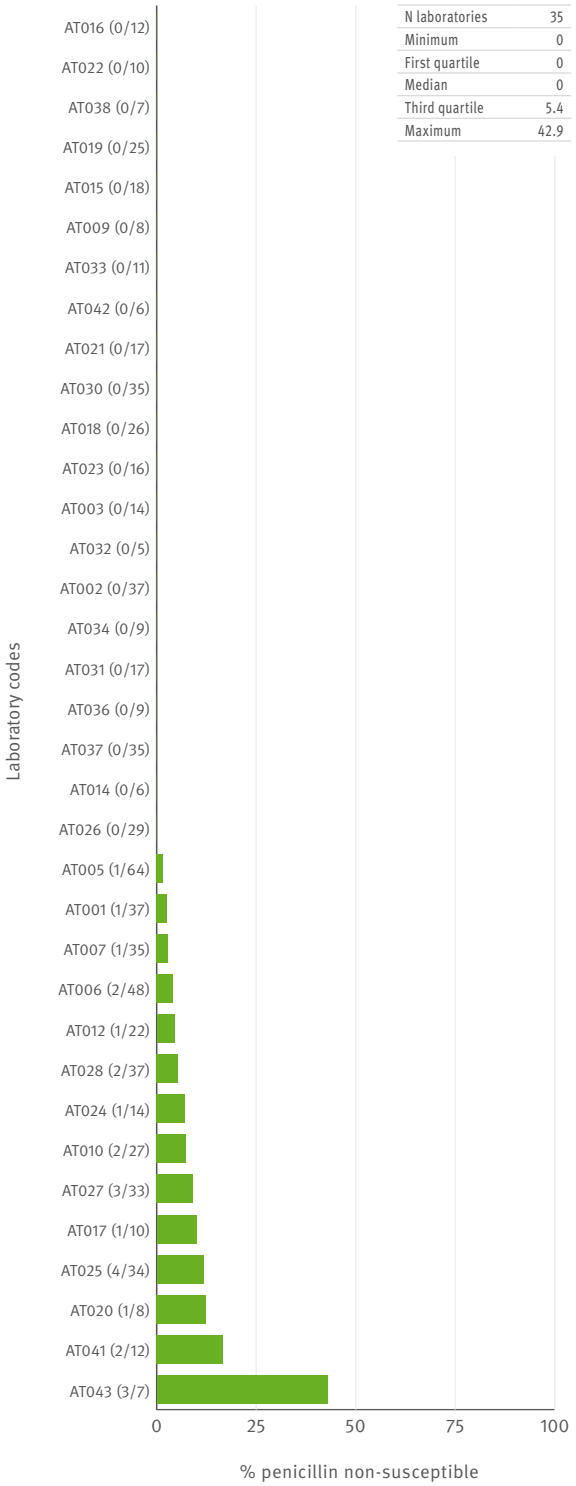


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

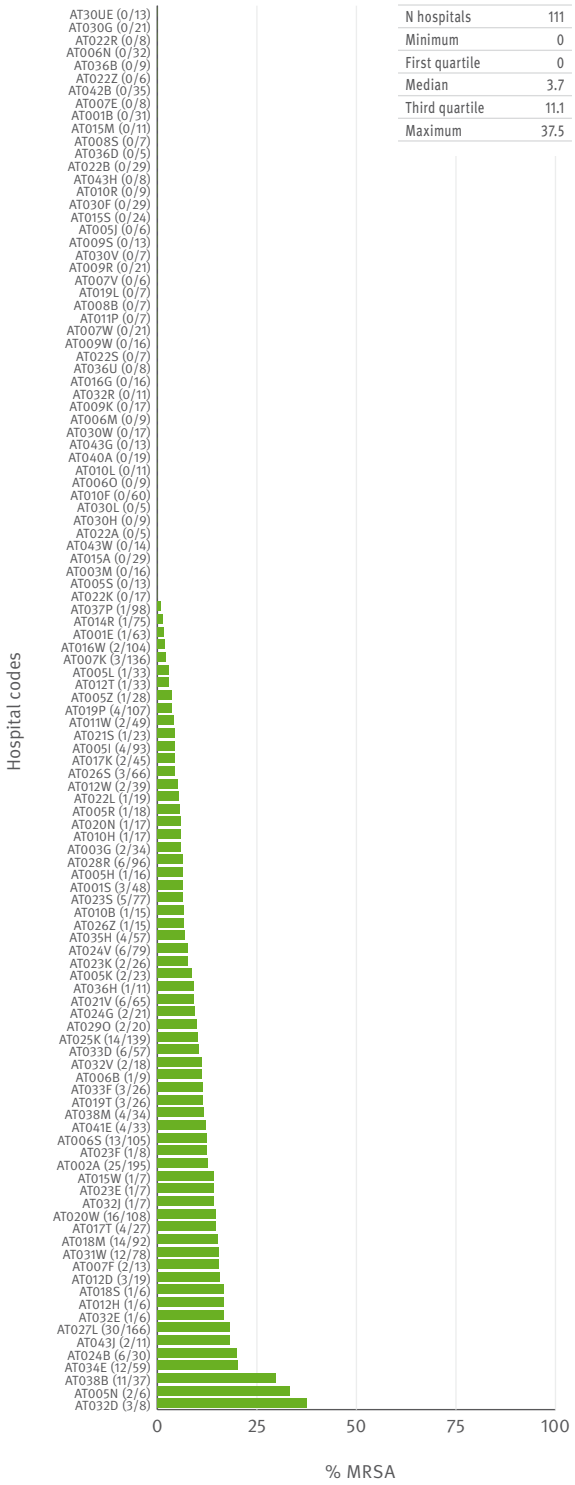


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

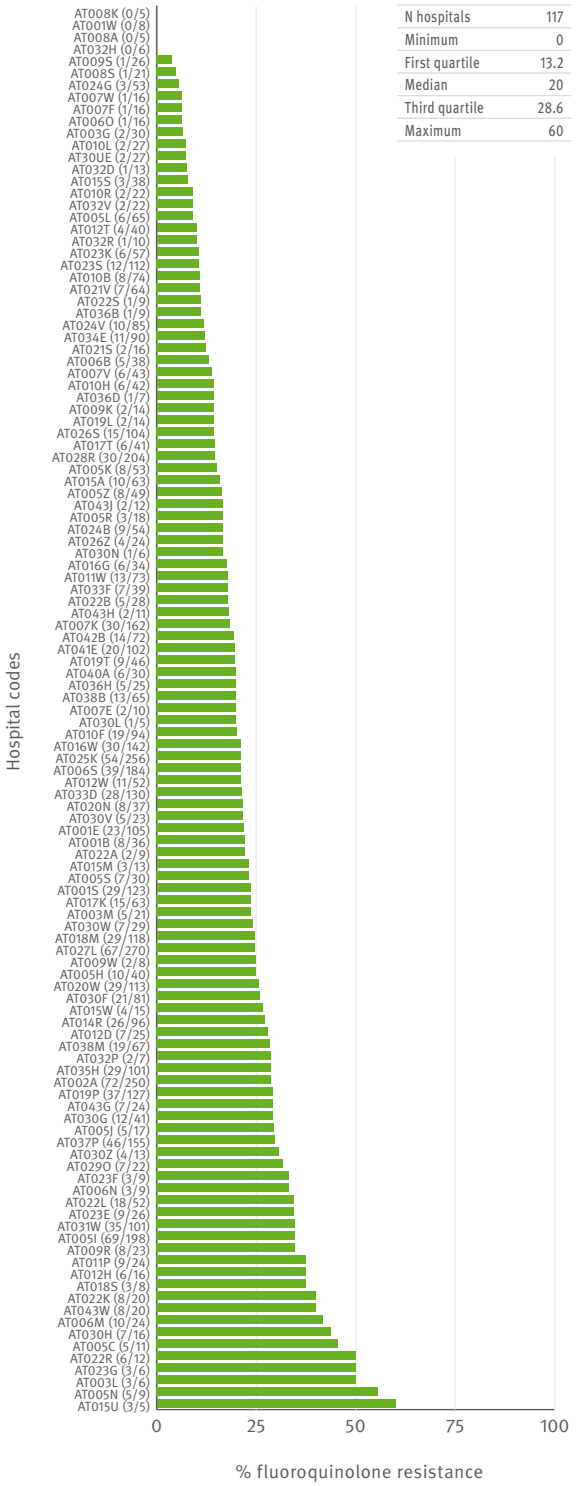
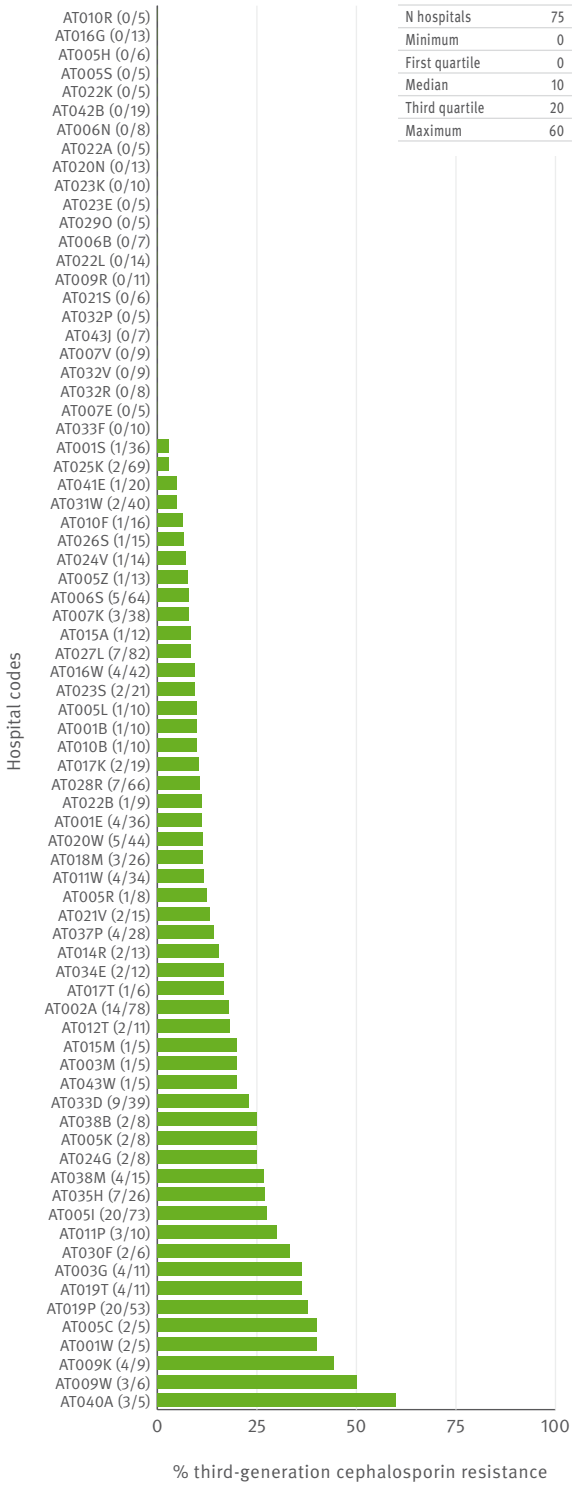


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Belgium

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	107	1488	47	1133	24	1326	16	146	-	-	-	-
2004	95	1443	49	1227	25	1601	18	228	-	-	-	-
2005	97	1539	41	1048	25	1592	19	223	-	-	-	-
2006	98	1427	33	858	21	1632	22	267	-	-	-	-
2007	105	1511	34	855	17	1460	20	245	-	-	-	-
2008	101	1647	38	906	16	1430	19	236	-	-	-	-
2009	101	1885	34	949	18	1610	14	227	8	142	8	136
2010	97	1797	40	1088	23	1966	22	323	14	145	15	130
2011	91	1829	50	1771	43	4039	46	754	44	676	43	460

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	3	4	3	<1	<1	<1	<1
Penicillin RI	12	9	12	10	9	8	<1	<1	<1
Macrolides RI	34	33	31	31	25	24	23	25	26
Staphylococcus aureus									
Oxacillin/Meticillin R	30	33	31	22	23	21	21	21	17
Escherichia coli									
Aminopenicilins R	50	50	53	54	57	55	56	57	59
Aminoglycosides R	5	5	4	6	5	4	7	6	9
Fluoroquinolones R	12	15	17	19	19	17	20	22	22
Third-gen. cephalosporins R	3	3	4	3	4	4	6	5	6
Carbapenems R	-	-	-	-	-	-	-	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	1	2	<1	<1	<1	3	1	2	2
HL Gentamicin R	17	22	26	30	26	30	23	18	18
Vancomycin R	1	<1	<1	<1	1	<1	1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	78	63	61	67	68	76	90	89	83
HL Gentamicin R	<1	11	22	19	23	17	32	30	33
Vancomycin R	<1	5	14	4	<1	5	4	3	7
Klebsiella pneumoniae									
Aminoglycosides R	-	-	-	-	-	-	10	2	8
Fluoroquinolones R	-	-	-	-	-	-	13	13	15
Third-gen. cephalosporins R	-	-	-	-	-	-	15	13	14
Carbapenems R	-	-	-	-	-	-	1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	-	-	-	7	12	15
Ceftazidime R	-	-	-	-	-	-	6	7	9
Carbapenems R	-	-	-	-	-	-	9	5	11
Aminoglycosides R	-	-	-	-	-	-	10	14	14
Fluoroquinolones R	-	-	-	-	-	-	16	12	21

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	96	0	100	19	100	22	100	0	100	6	100	13	99	9
CSF	4	15	-	-	0	0	-	-	-	-	0	0	1	20
Gender														
Male	55	1	59	19	47	26	63	0	58	6	58	13	62	9
Female	44	1	40	18	53	18	37	0	42	5	42	14	38	9
Unknown	1	2	<1	11	<1	100	0	0	0	0	-	-	-	-
Age (years)														
0–4	17	1	5	8	3	6	6	0	1	0	2	13	2	7
5–19	5	1	3	4	1	18	0	0	0	0	<1	25	2	20
20–64	35	1	36	15	28	17	27	0	34	6	33	13	30	14
65 and over	42	0	57	23	69	24	67	0	64	5	64	14	66	7
Unknown	1	0	0	0	-	-	0	0	1	50	-	-	-	-
Hospital department														
ICU	8	2	1	24	1	17	1	0	2	0	1	29	0	0
Internal med.	-	-	1	10	<1	27	-	-	-	-	-	-	-	-
Surgery	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	43	1	61	17	66	22	69	0	71	7	82	13	78	11
Unknown	50	0	38	21	33	22	30	0	27	3	18	13	22	5

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Belgium

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

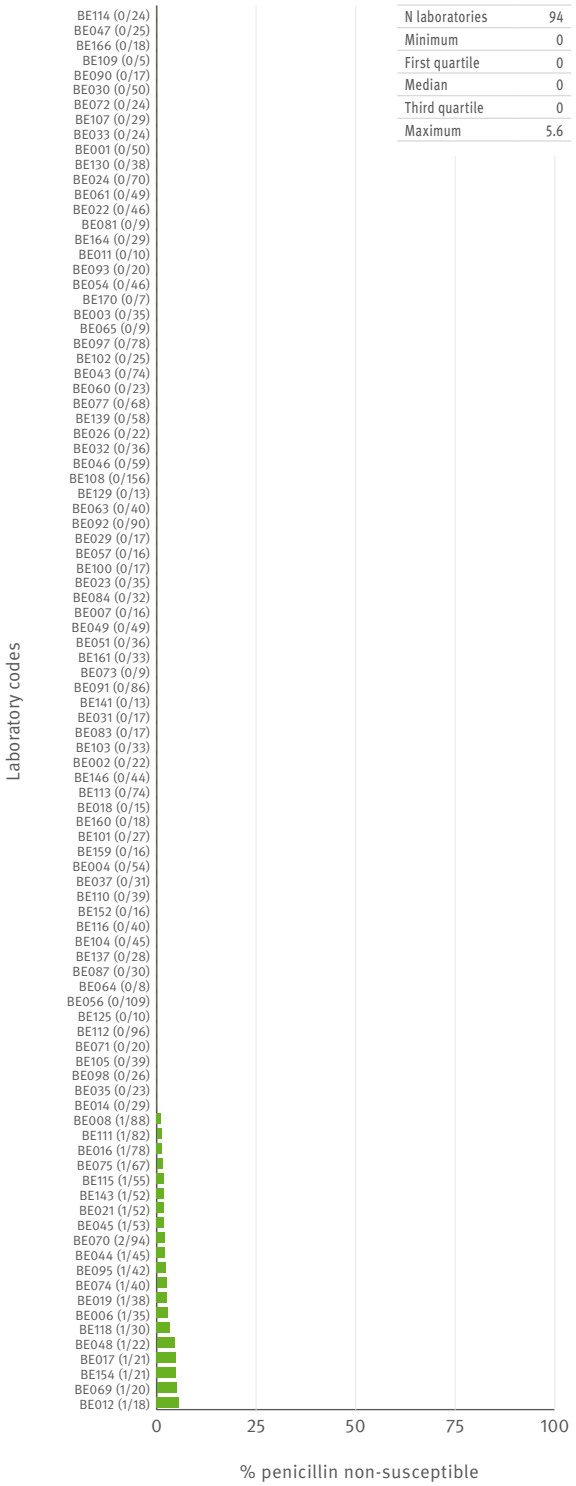


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

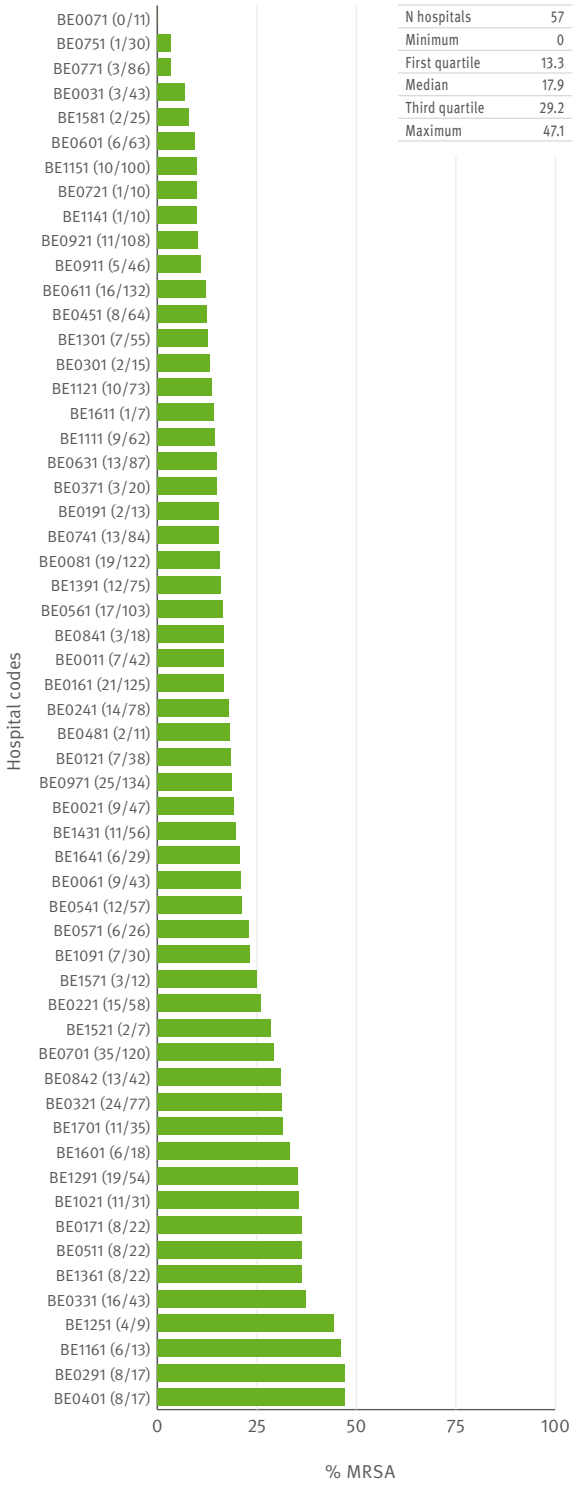


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

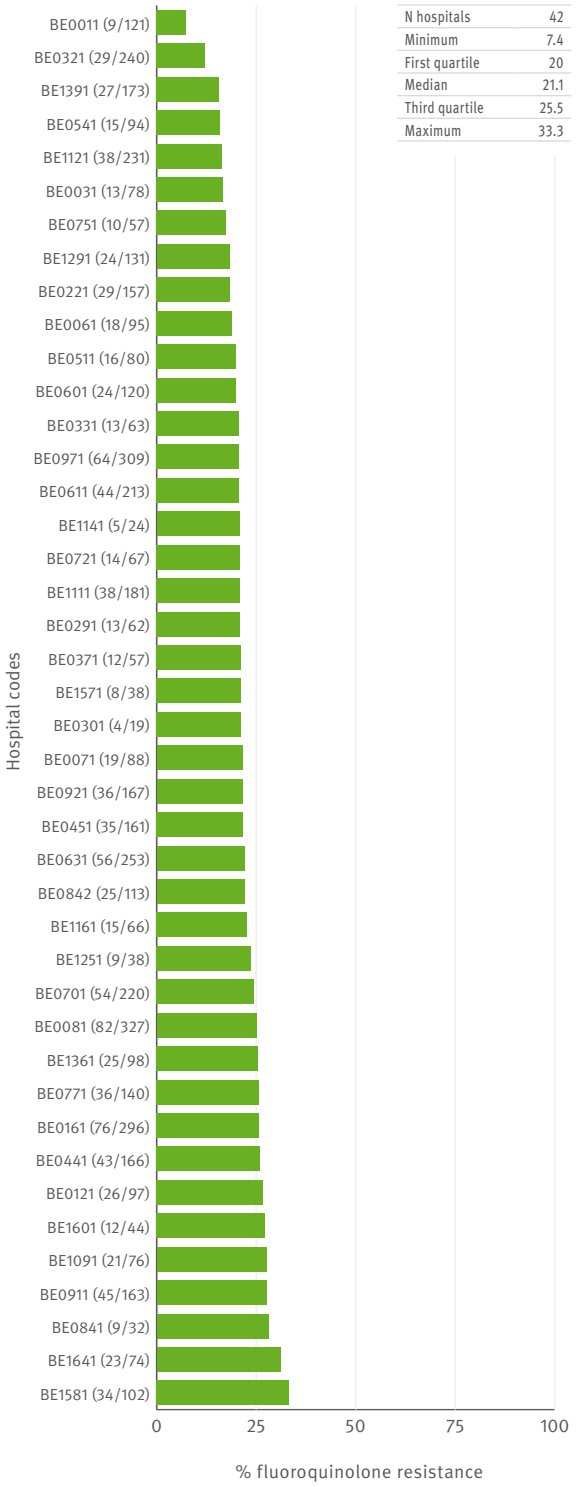
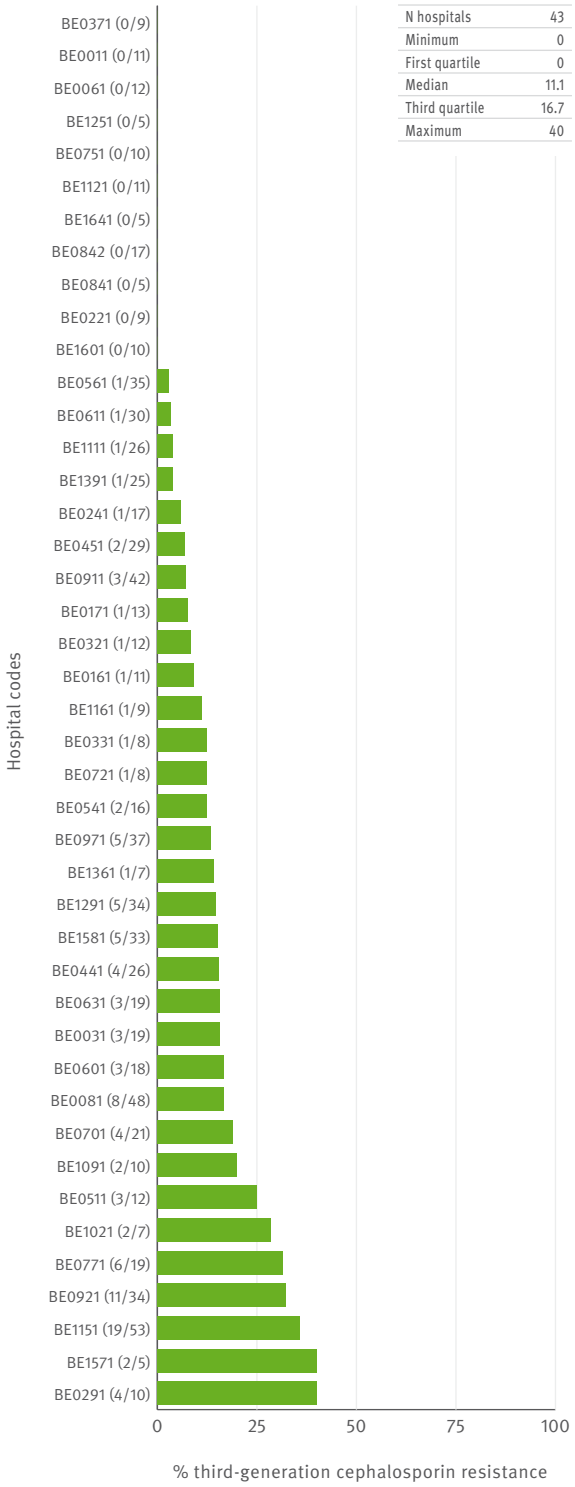


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Bulgaria

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	13	22	20	157	20	158	16	49	-	-	-	-
2004	13	32	22	170	20	167	16	75	-	-	-	-
2005	16	43	26	160	23	203	21	95	15	34	9	34
2006	11	29	23	159	20	196	19	98	15	55	13	31
2007	10	32	14	121	15	127	13	65	9	29	6	14
2008	13	29	21	160	22	147	18	70	11	49	10	23
2009	10	27	20	221	17	194	16	92	12	95	11	36
2010	13	22	20	200	21	153	16	108	15	127	11	42
2011	16	33	19	214	19	179	16	117	15	121	12	48

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	9	22	30	7	9	21	22	18	21
Penicillin RI	14	22	33	7	16	21	37	18	21
Macrolides RI	11	17	8	15	17	4	27	25	13
Staphylococcus aureus									
Oxacillin/Meticillin R	31	23	29	28	13	25	16	19	22
Escherichia coli									
Aminopenicilins R	54	64	69	64	70	65	66	72	61
Aminoglycosides R	22	20	24	28	20	31	18	16	17
Fluoroquinolones R	19	24	29	26	35	32	28	33	30
Third-gen. cephalosporins R	18	22	28	29	23	29	19	25	23
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	7	15	8	31	13	8	16	5	6
HL Gentamicin R	36	33	24	53	29	44	36	41	31
Vancomycin R	<1	2	<1	2	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	60	59	96	97	100	93	96	100	84
HL Gentamicin R	60	62	56	79	75	84	65	71	79
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	53	60	59	59	65	69	72
Fluoroquinolones R	-	-	26	24	41	52	48	52	51
Third-gen. cephalosporins R	-	-	50	60	55	73	69	76	81
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	50	33	14	48	33	15	23
Ceftazidime R	-	-	45	13	21	55	23	19	31
Carbapenems R	-	-	38	14	7	17	24	31	29
Aminoglycosides R	-	-	53	42	29	48	33	19	33
Fluoroquinolones R	-	-	47	17	14	36	33	21	30

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	64	20	100	21	98	32	100	0	100	0	98	79	97	30
CSF	36	20	-	-	2	17	-	-	-	-	2	50	3	33
Gender														
Male	56	23	64	22	54	34	63	0	61	0	65	78	60	31
Female	44	17	35	17	46	28	37	0	39	0	35	78	40	28
Unknown	-	-	1	67	0	0	-	-	-	-	-	-	-	-
Age (years)														
0–4	15	38	3	42	2	20	3	0	5	0	9	91	8	29
5–19	11	33	4	24	2	14	1	0	3	0	2	100	1	0
20–64	42	17	42	21	35	32	45	0	48	0	32	85	40	33
65 and over	24	15	30	22	42	33	35	0	26	0	23	68	30	7
Unknown	9	0	21	14	19	30	16	0	18	0	34	74	21	58
Hospital department														
ICU	18	10	19	34	17	44	22	0	32	0	19	79	34	52
Internal med.	24	15	38	11	47	25	31	0	16	0	21	51	17	7
Surgery	-	-	11	35	10	42	13	0	19	0	13	94	9	0
Other	58	25	32	20	26	31	33	0	32	0	46	86	40	28
Unknown	-	-	0	0	-	-	1	0	-	-	1	67	-	-

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Bulgaria

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

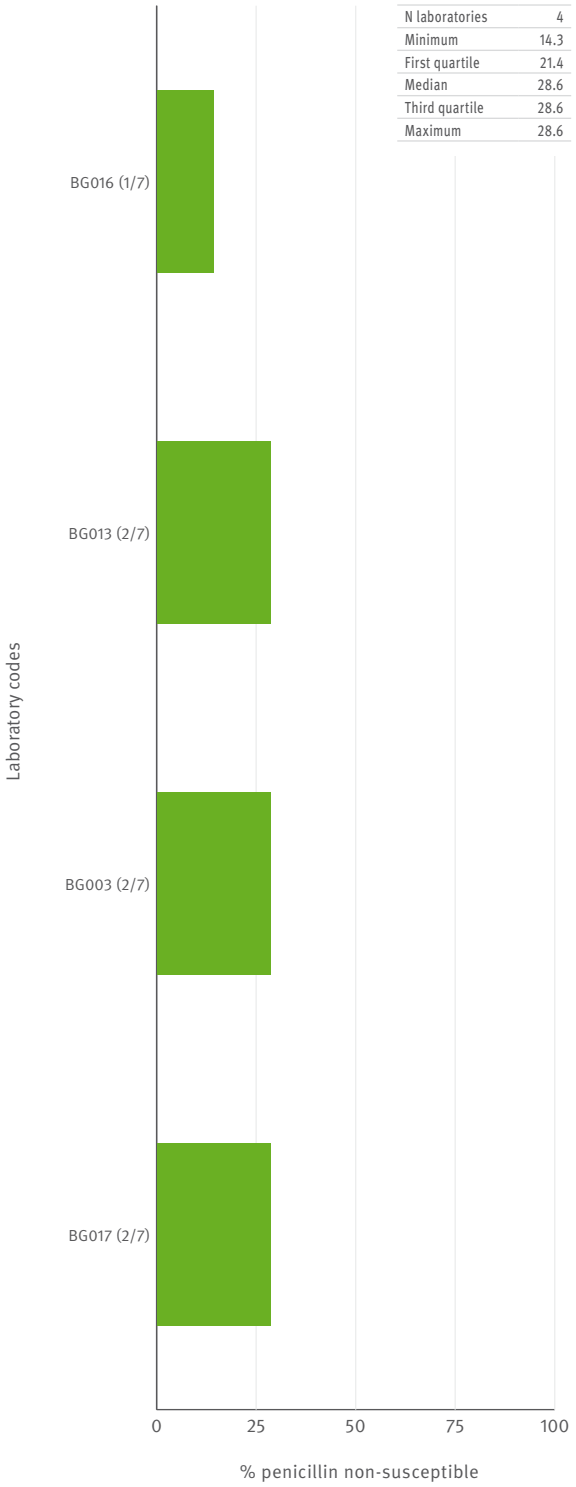


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

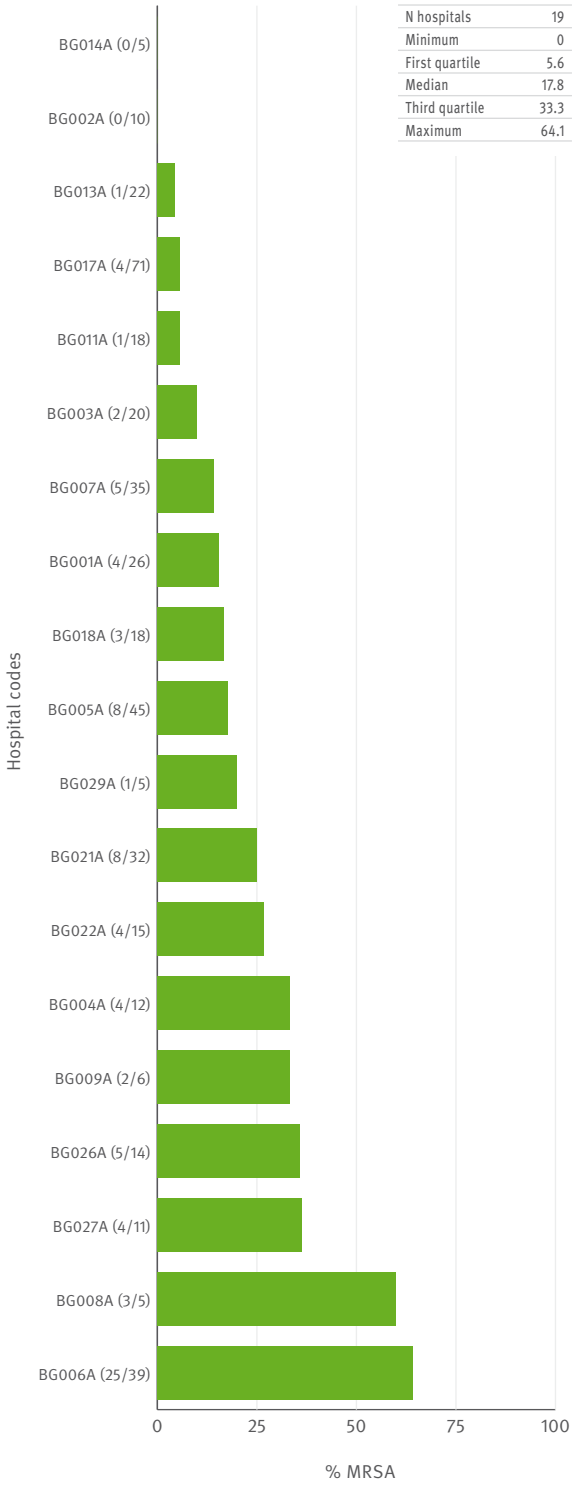


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

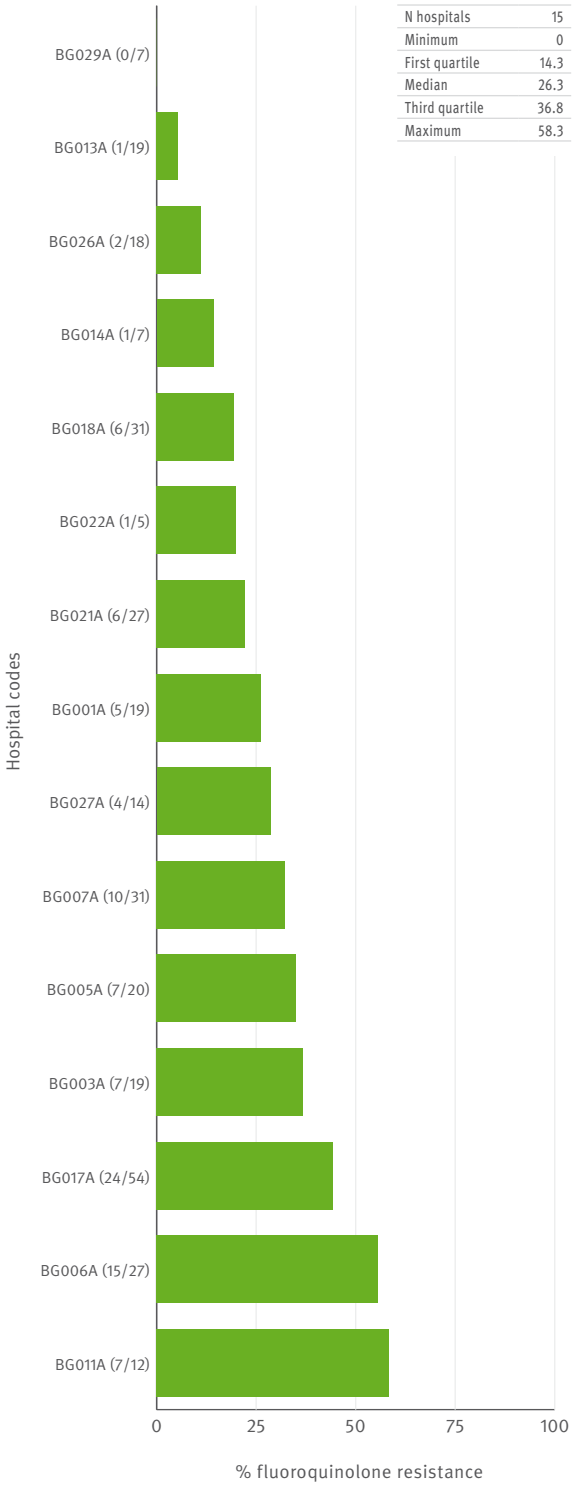
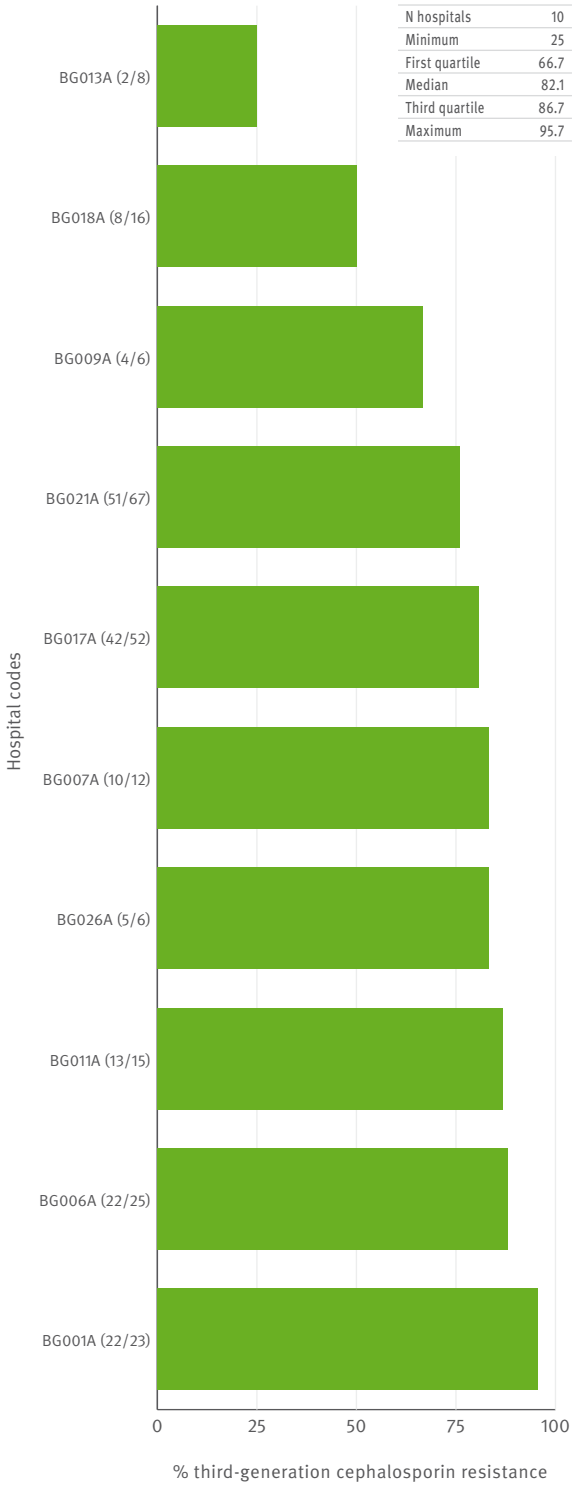


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Cyprus

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	1	3	1	28	1	19	1	28	-	-	-	-
2004	1	7	3	39	4	46	3	38	-	-	-	-
2005	4	16	5	54	5	75	3	40	4	9	4	8
2006	5	13	5	62	5	90	4	48	4	26	4	37
2007	4	15	4	85	5	109	3	63	4	39	3	52
2008	4	14	5	92	4	119	5	85	5	62	5	43
2009	4	11	5	89	5	136	5	80	5	53	5	62
2010	4	12	5	99	5	139	5	91	4	67	5	48
2011	2	12	4	113	5	138	4	71	4	83	4	51

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	31	7	21	18	33	25
Penicillin RI	<1	14	19	38	33	43	36	42	25
Macrolides RI	33	<1	13	31	27	29	36	55	25
Staphylococcus aureus									
Oxacillin/Meticillin R	64	49	56	34	48	46	33	32	42
Escherichia coli									
Aminopenicilins R	63	61	72	62	72	58	66	62	78
Aminoglycosides R	11	11	13	10	11	10	10	16	24
Fluoroquinolones R	32	22	29	35	39	45	43	43	47
Third-gen. cephalosporins R	11	9	16	16	18	19	14	20	36
Carbapenems R	<1	<1	<1	<1	2	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	3	3	5	2	16	32	6	2
HL Gentamicin R	43	77	71	44	61	65	66	24	19
Vancomycin R	<1	3	<1	<1	<1	1	<1	<1	4
Enterococcus faecium									
Aminopenicilins RI	100	100	80	43	92	60	80	78	82
HL Gentamicin R	-	33	<1	14	33	10	13	<1	6
Vancomycin R	<1	33	40	14	25	20	13	<1	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	11	12	13	21	19	19	28
Fluoroquinolones R	-	-	22	12	23	23	43	39	36
Third-gen. cephalosporins R	-	-	33	27	31	35	42	34	41
Carbapenems R	-	-	<1	<1	3	10	17	16	16
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	13	27	31	23	18	19	20
Ceftazidime R	-	-	38	24	15	9	18	17	24
Carbapenems R	-	-	13	11	19	19	8	29	43
Aminoglycosides R	-	-	13	11	25	21	5	10	16
Fluoroquinolones R	-	-	13	27	23	38	13	17	14

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	83	25	100	37	100	45	100	2	100	0	98	38	98	36
CSF	17	75	-	-	<1	100	-	-	-	-	2	33	2	50
Gender														
Male	67	31	61	36	41	61	55	0	65	0	55	46	66	42
Female	29	29	34	39	56	35	43	0	33	0	41	31	29	21
Unknown	4	100	5	45	3	13	2	67	3	0	5	0	5	60
Age (years)														
0–4	4	100	5	18	3	43	3	0	3	0	4	0	2	50
5–19	13	33	0	0	-	-	1	0	-	-	1	0	1	0
20–64	13	0	25	30	20	49	27	0	43	0	35	33	30	43
65 and over	42	40	42	48	48	50	48	0	38	0	34	51	38	26
Unknown	29	29	27	33	29	35	20	8	18	0	26	36	28	43
Hospital department														
ICU	4	0	20	57	12	50	48	2	40	0	33	58	39	49
Internal med.	71	24	60	28	69	46	34	0	23	0	39	27	36	17
Surgery	-	-	9	65	7	53	7	0	5	0	11	47	8	38
Other	21	60	6	23	8	30	8	0	23	0	16	17	11	36
Unknown	4	100	4	33	3	22	2	33	10	0	-	-	5	80

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Cyprus

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

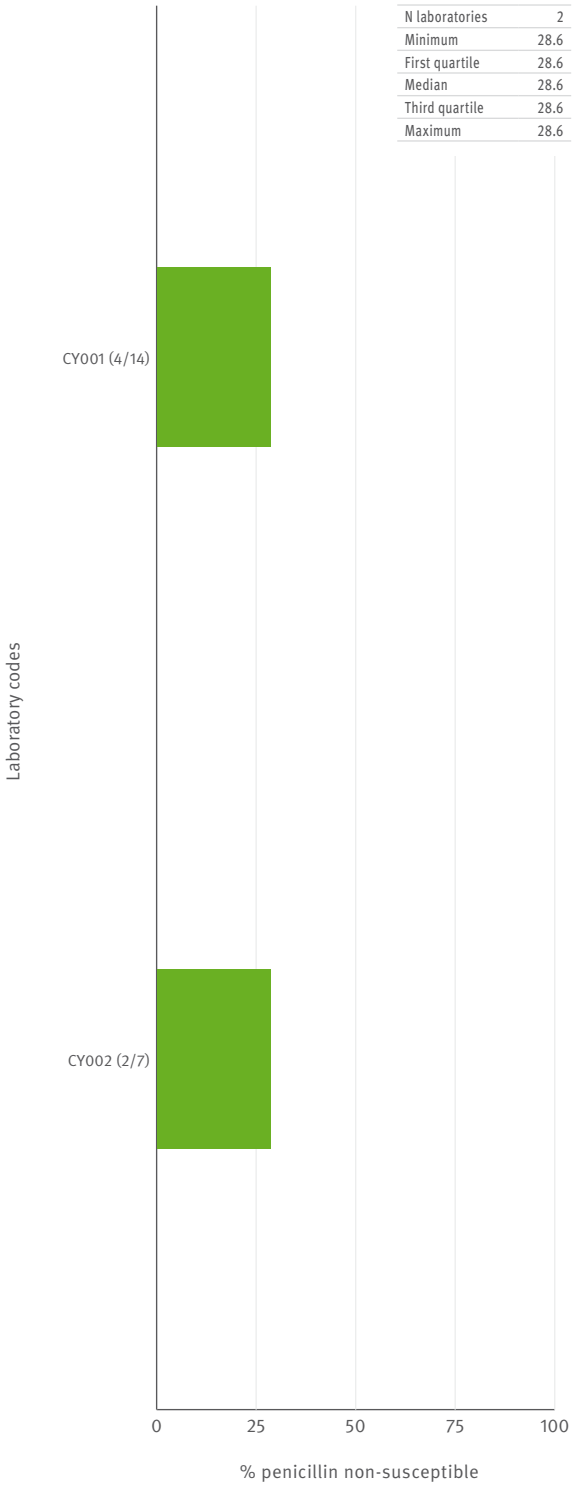


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

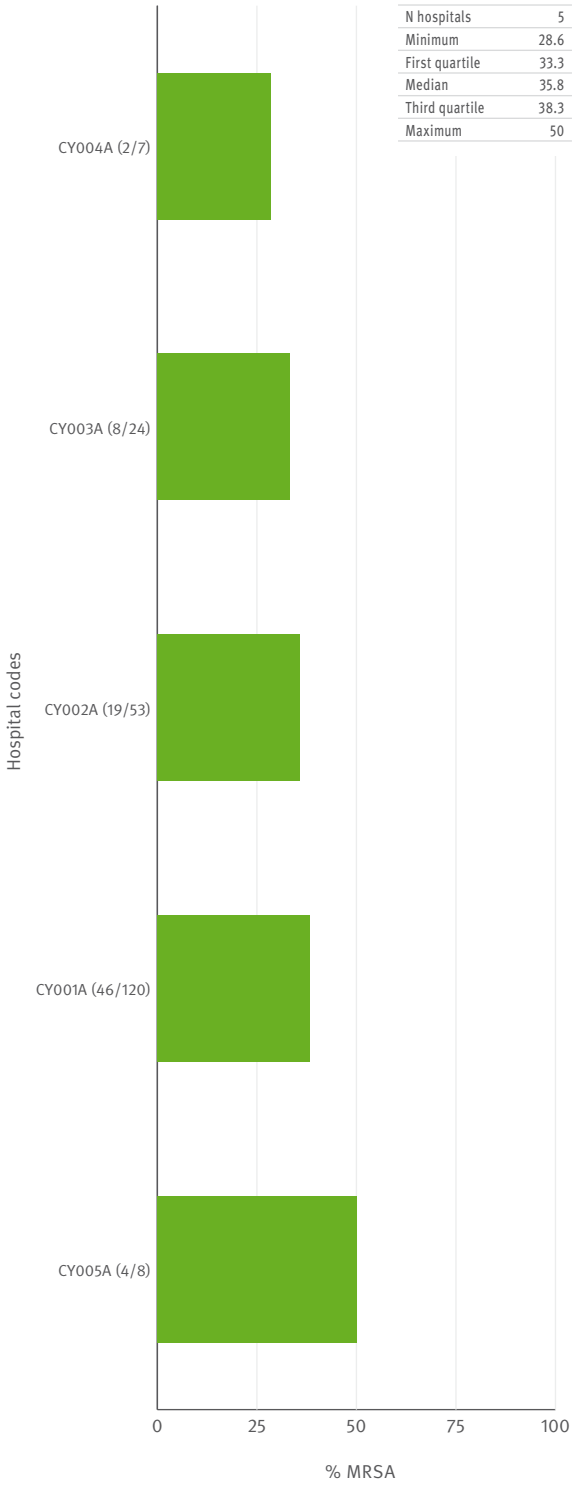


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

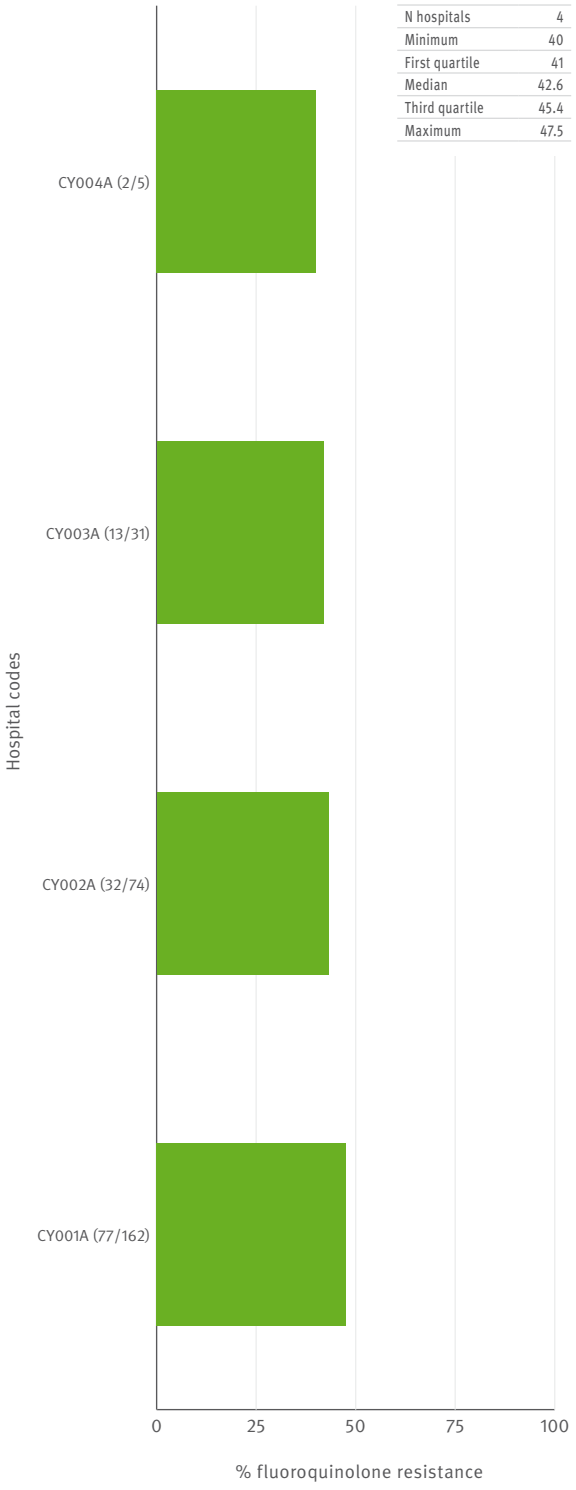
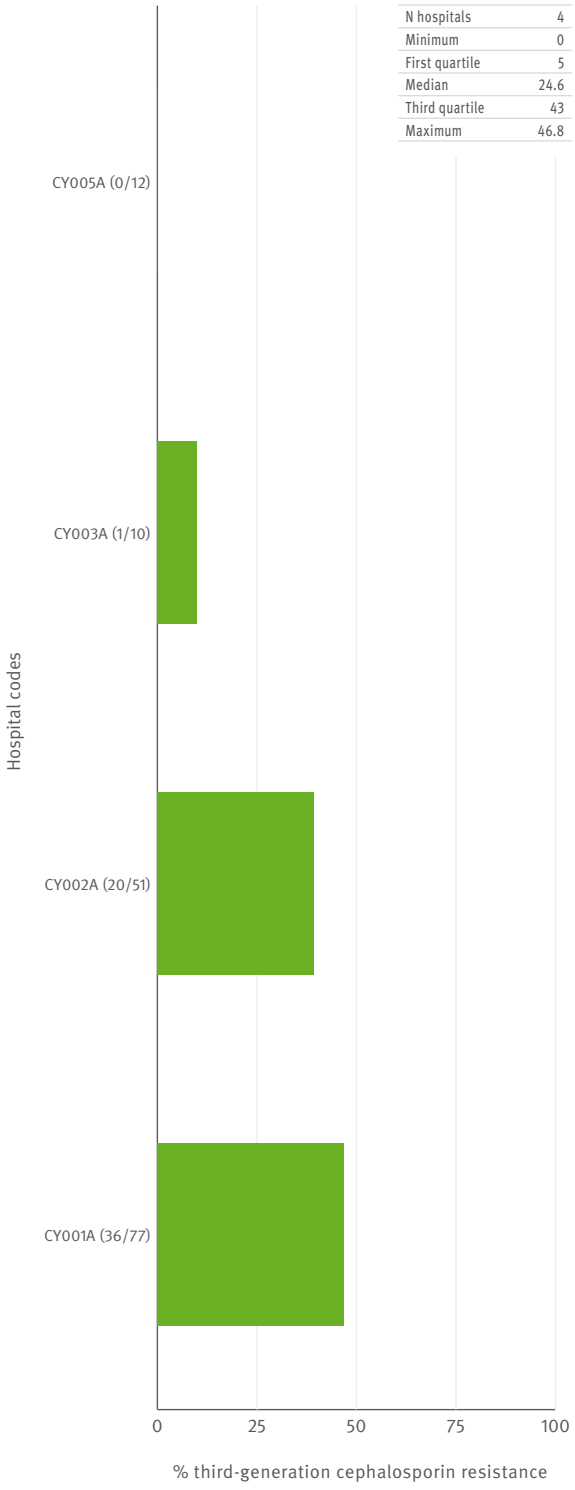


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Czech Republic

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	32	204	45	1387	43	1766	44	630	-	-	-	-
2004	37	162	45	1444	44	1966	41	660	-	-	-	-
2005	39	195	47	1553	47	2234	45	758	37	478	36	257
2006	39	172	47	1527	47	2176	45	697	45	1130	43	490
2007	41	205	47	1653	48	2407	47	816	48	1230	41	517
2008	40	244	47	1715	46	2738	44	883	45	1493	42	568
2009	41	297	46	1695	45	2759	44	835	45	1415	45	575
2010	41	288	44	1593	43	2484	41	759	44	1264	41	511
2011	42	316	46	1555	45	2696	44	767	44	1287	42	448

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	2	<1	<1	<1	<1	<1	<1	<1
Penicillin RI	2	6	4	2	4	3	4	5	4
Macrolides RI	2	4	2	3	5	3	5	6	3
Staphylococcus aureus									
Oxacillin/Meticillin R	6	9	13	12	13	14	15	13	15
Escherichia coli									
Aminopenicilins R	45	47	50	56	56	60	61	59	61
Aminoglycosides R	5	5	6	8	7	9	9	8	9
Fluoroquinolones R	13	16	20	23	24	26	23	23	23
Third-gen. cephalosporins R	1	2	2	5	7	10	10	10	11
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	<1	<1	2	3	2	<1	8	4
HL Gentamicin R	44	43	45	43	49	49	47	48	46
Vancomycin R	<1	<1	<1	<1	1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	80	81	92	90	91	94	98	98	97
HL Gentamicin R	48	43	69	74	79	75	65	54	61
Vancomycin R	3	3	14	4	6	8	6	5	8
Klebsiella pneumoniae									
Aminoglycosides R	-	-	36	38	43	42	47	47	45
Fluoroquinolones R	-	-	38	47	48	52	54	55	53
Third-gen. cephalosporins R	-	-	32	35	46	48	52	48	48
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	21	29	30	27	28	28	22
Ceftazidime R	-	-	40	30	33	44	29	28	20
Carbapenems R	-	-	31	33	36	29	29	16	13
Aminoglycosides R	-	-	28	30	34	45	32	32	24
Fluoroquinolones R	-	-	45	47	43	46	41	41	34

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	86	4	100	14	100	23	100	0	100	6	99	48	100	15
CSF	14	5	-	-	0	0	-	-	-	-	1	41	0	0
Gender														
Male	60	3	62	14	43	27	65	1	64	6	60	50	62	15
Female	40	6	38	15	57	20	35	0	36	7	40	46	38	14
Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Age (years)														
0–4	5	3	5	1	2	9	4	2	2	0	1	39	1	17
5–19	5	0	2	1	1	20	1	0	2	14	1	60	2	16
20–64	47	5	41	13	29	21	39	0	48	10	42	51	42	18
65 and over	42	5	52	17	68	25	56	1	49	2	56	46	54	13
Hospital department														
ICU	25	5	26	17	19	26	46	0	38	1	42	56	49	19
Internal med.	37	4	43	14	50	22	26	1	18	5	31	40	23	7
Surgery	1	0	8	14	5	23	6	0	7	8	7	39	5	13
Other	32	5	23	10	26	23	22	0	37	12	20	47	23	15
Unknown	5	6	0	21	0	0	0	0	-	-	0	75	-	-

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Czech Republic

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

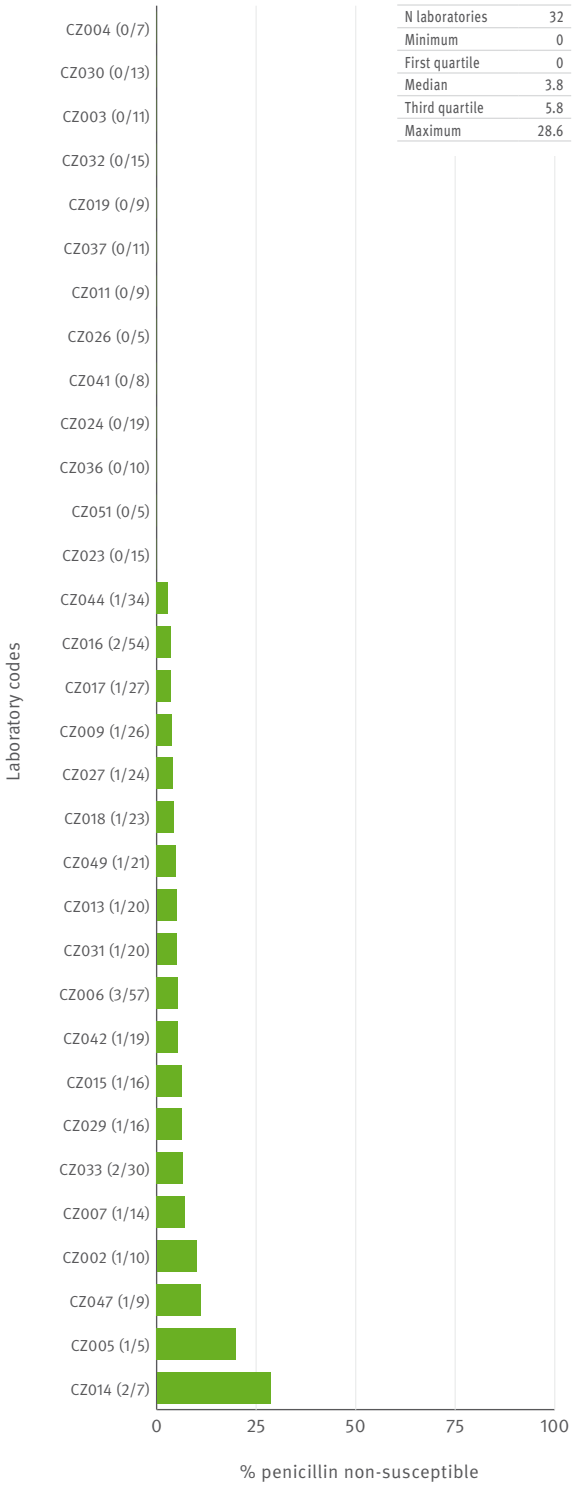


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

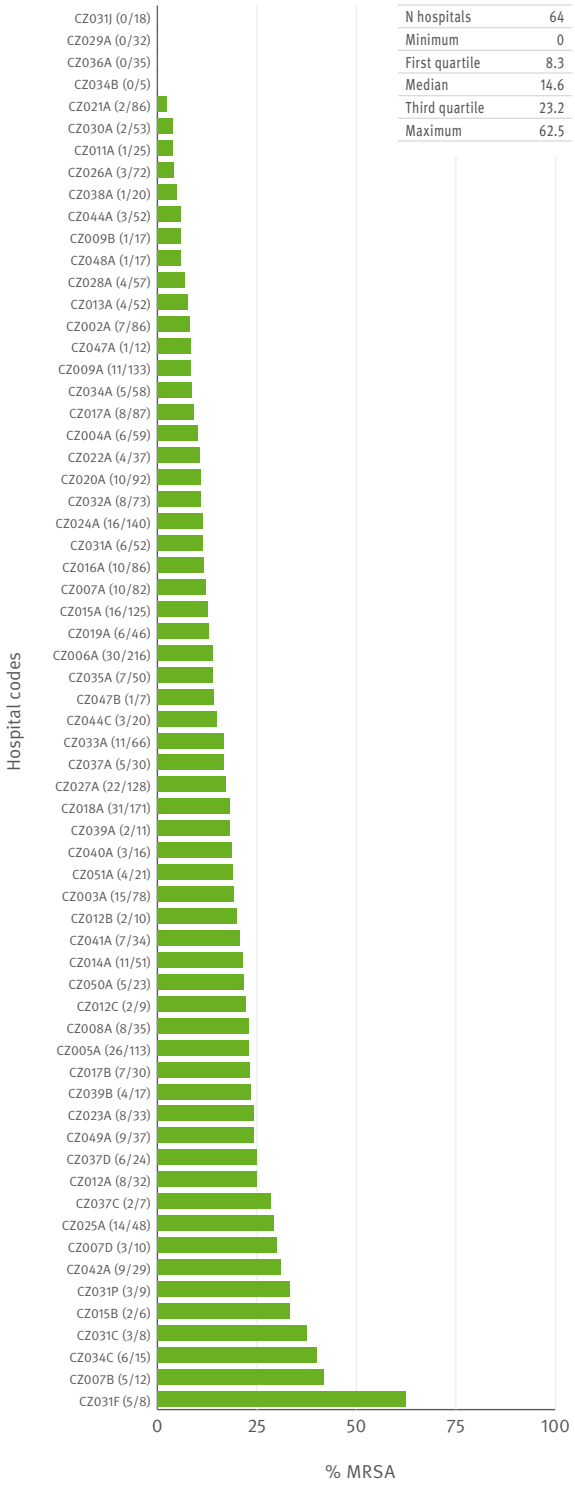


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

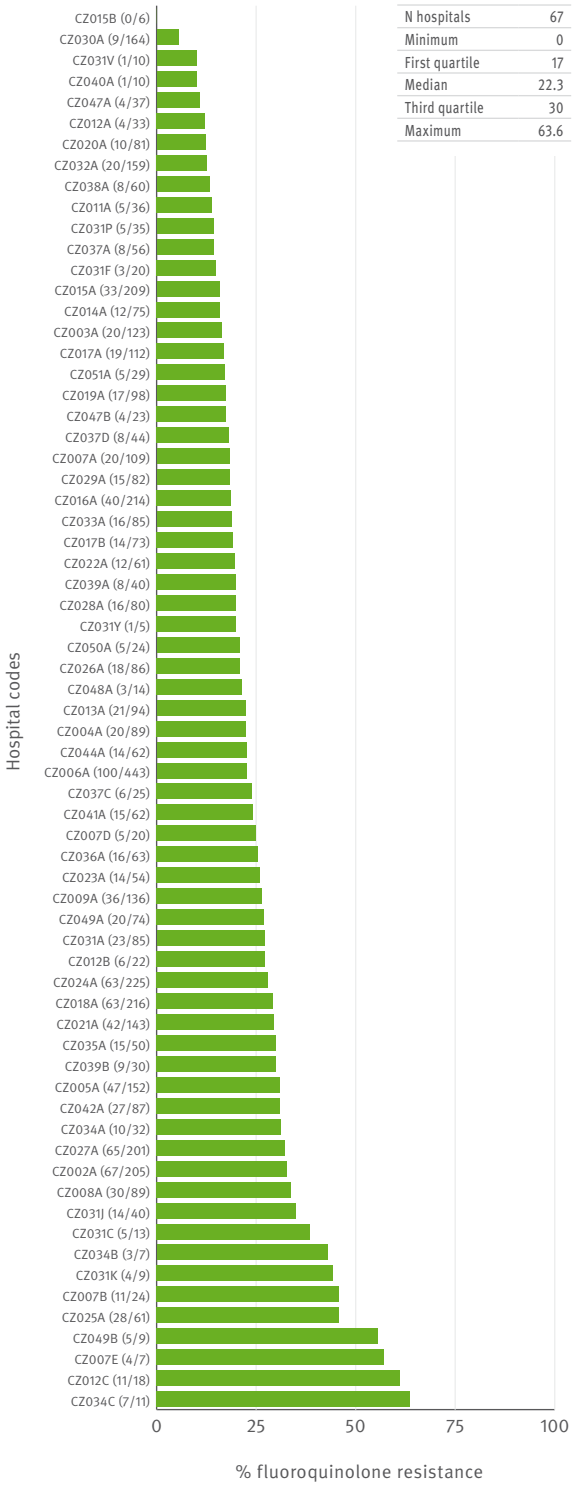
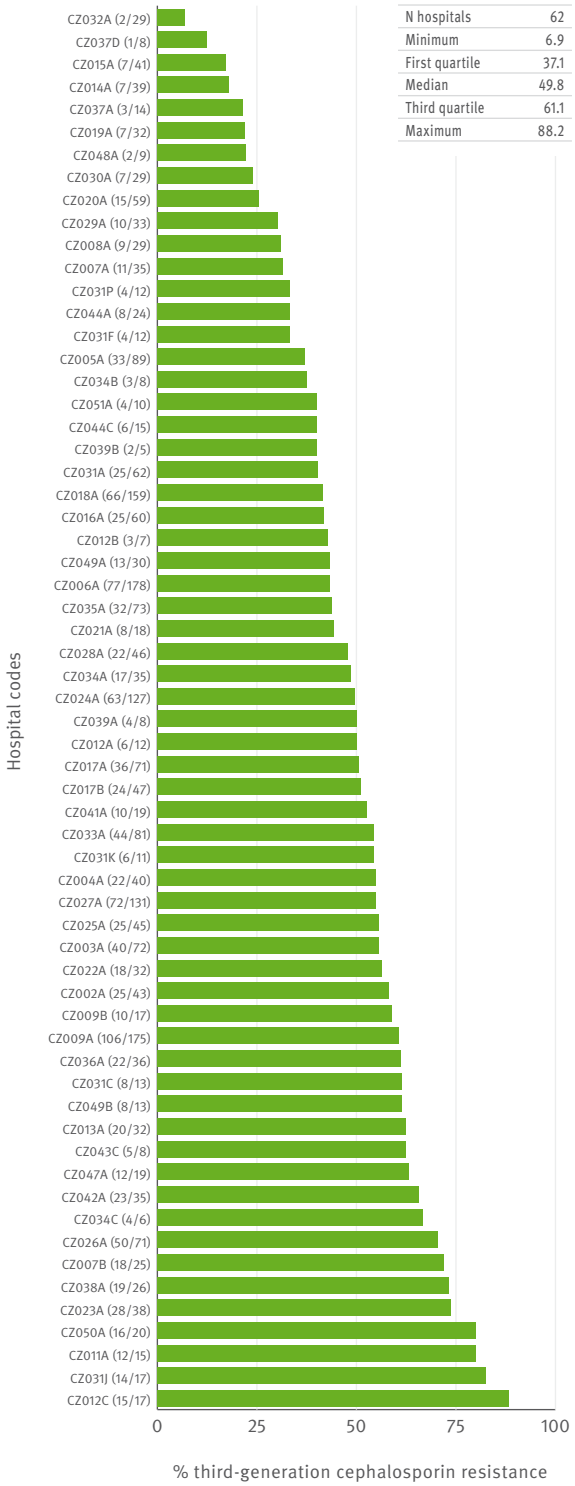


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Denmark

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	5	606	5	671	-	-	-	-	-	-	-	-
2004	15	1188	15	1436	-	-	-	-	-	-	-	-
2005	14	1081	15	1350	5	1283	-	-	-	-	-	-
2006	15	872	15	1279	11	2723	11	711	11	607	-	-
2007	15	1030	14	1315	12	3021	13	927	13	784	13	417
2008	15	934	15	1295	14	3283	14	1005	14	793	14	420
2009	15	996	15	1395	14	3532	14	1100	14	822	14	429
2010	15	954	15	1362	14	3418	14	1112	14	799	14	376
2011	13	896	13	1452	12	3642	12	1197	12	910	12	407

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Penicillin RI	3	3	4	4	3	3	4	4	5
Macrolides RI	5	5	6	6	6	7	4	4	5
Staphylococcus aureus									
Oxacillin/Meticillin R	<1	1	2	2	<1	2	2	1	1
Escherichia coli									
Aminopenicilins R	-	-	40	42	43	43	43	46	48
Aminoglycosides R	-	-	2	3	4	4	4	6	6
Fluoroquinolones R	-	-	5	7	9	10	13	14	14
Third-gen. cephalosporins R	-	-	1	2	3	4	6	8	8
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	-	-	-	<1	2	2	1	<1	<1
HL Gentamicin R	-	-	-	.	.	37	33	36	31
Vancomycin R	-	-	-	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	-	-	-	87	88	88	88	93	93
HL Gentamicin R	-	-	-	.	.	61	52	74	73
Vancomycin R	-	-	-	<1	<1	<1	2	2	1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	-	2	6	7	7	6	6
Fluoroquinolones R	-	-	-	6	13	16	16	11	12
Third-gen. cephalosporins R	-	-	-	4	10	9	11	11	11
Carbapenems R	-	-	-	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	-	3	2	2	4	5
Ceftazidime R	-	-	-	-	2	3	4	3	5
Carbapenems R	-	-	-	-	2	1	3	3	5
Aminoglycosides R	-	-	-	-	1	1	<1	1	2
Fluoroquinolones R	-	-	-	-	6	3	5	6	7

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	93	4	100	1	100	14	100	0	100	2	100	11	99	4
CSF	7	4	-	-	<1	13	-	-	-	-	0	0	1	0
Gender														
Male	51	4	63	1	48	16	70	0	61	1	58	12	67	5
Female	49	4	37	1	51	12	27	0	36	2	39	10	30	3
Unknown	-	-	-	-	2	14	3	3	3	3	3	3	3	0
Age (years)														
0–4	4	6	3	1	2	12	3	0	1	0	2	9	1	0
5–19	3	0	3	3	1	12	1	0	1	0	2	24	1	14
20–64	40	4	39	1	28	18	30	0	40	2	33	12	28	7
65 and over	54	5	55	1	69	13	67	0	59	1	63	10	69	3
Hospital department														
ICU	-	-	<1	8	4	14	12	1	29	2	5	22	6	9
Internal med.	-	-	7	1	44	13	42	0	21	0	45	9	38	4
Surgery	-	-	1	0	15	13	19	1	21	1	18	14	16	5
Other	-	-	5	1	27	15	23	0	20	3	28	9	29	5
Unknown	100	4	86	1	11	14	5	0	9	1	5	16	11	1

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Denmark

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

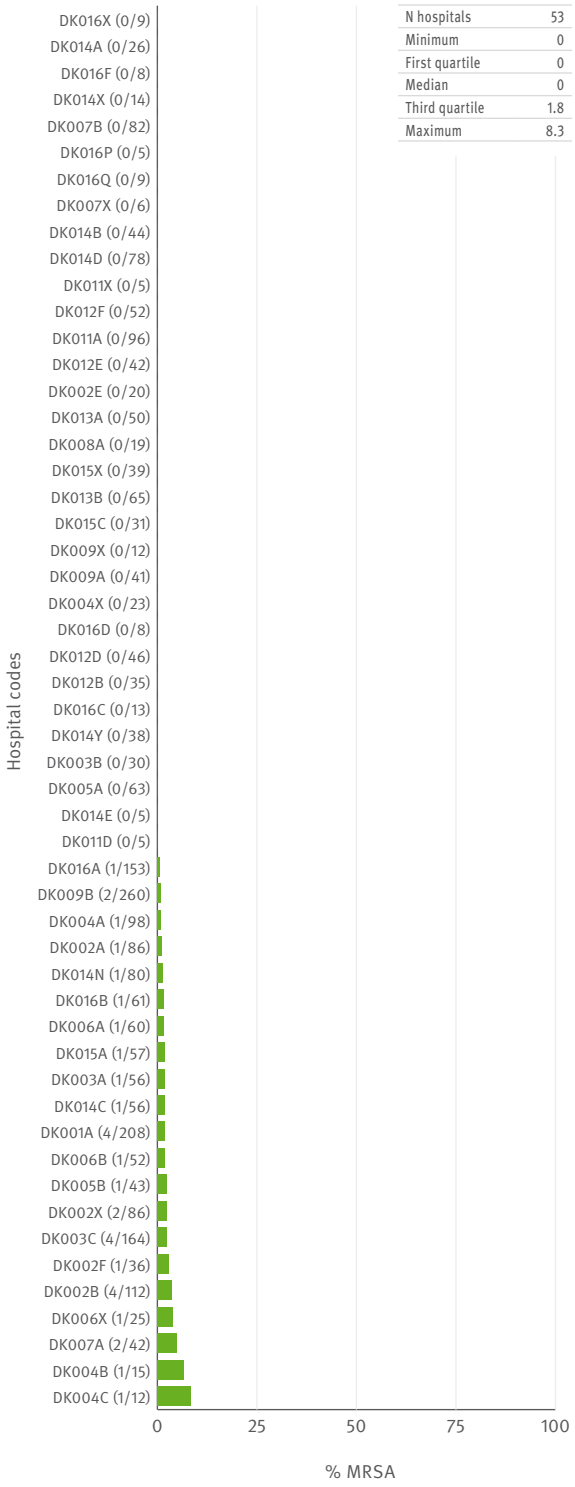


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

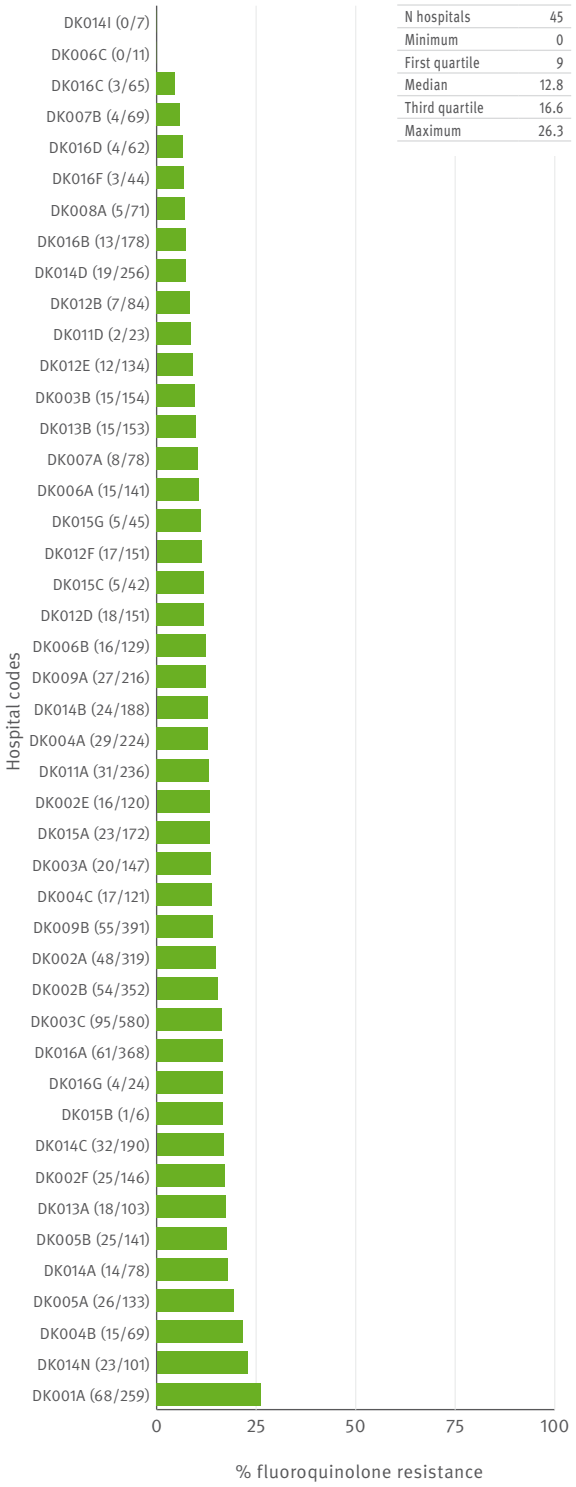
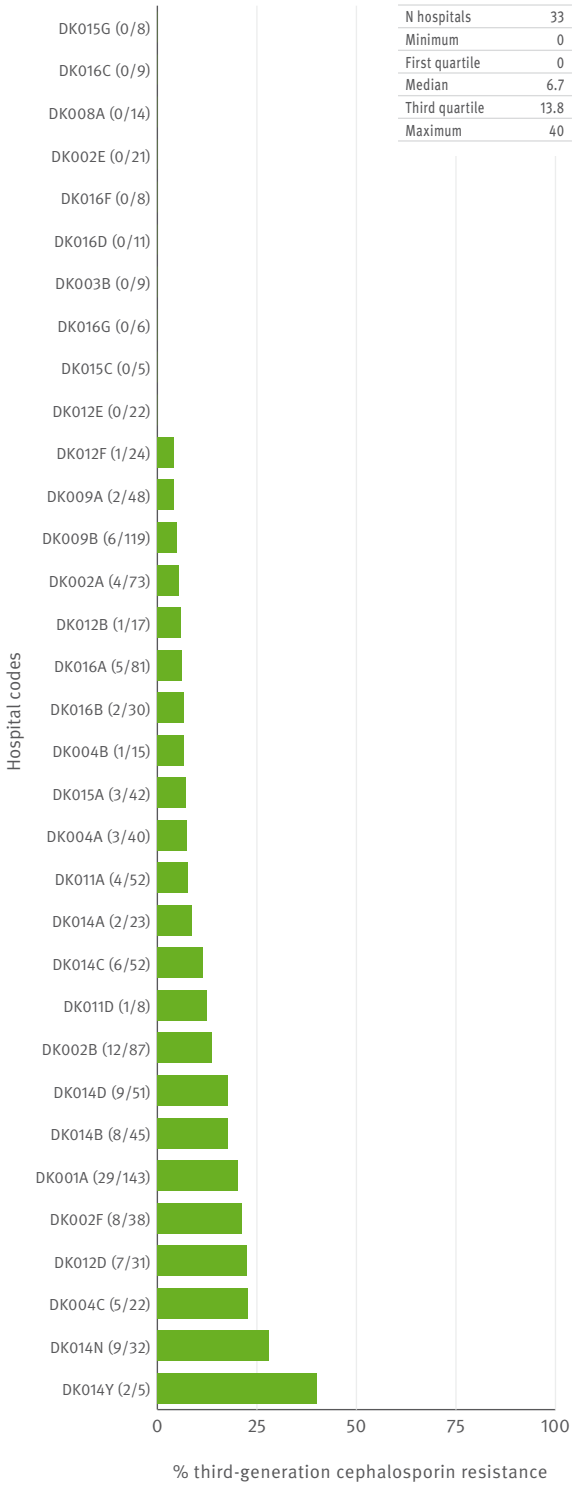


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Estonia

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	8	26	9	98	9	98	6	27	-	-	-	-
2004	6	40	9	104	10	167	5	63	-	-	-	-
2005	7	53	8	141	10	156	7	66	7	38	5	38
2006	8	52	9	154	9	215	8	85	6	47	6	43
2007	8	64	10	206	11	219	8	66	9	63	8	48
2008	10	66	11	185	11	267	11	86	10	72	8	41
2009	8	82	11	213	11	320	8	72	7	60	6	43
2010	10	64	9	152	11	317	8	66	9	82	8	43
2011	9	54	11	121	11	315	8	77	6	91	6	17

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	<1	<1	<1	<1	2	2
Penicillin RI	<1	<1	2	2	<1	5	1	2	2
Macrolides RI	10	6	<1	3	2	4	2	4	2
Staphylococcus aureus									
Oxacillin/Meticillin R	4	5	2	3	9	4	3	<1	2
Escherichia coli									
Aminopenicilins R	42	55	45	52	50	47	38	37	-
Aminoglycosides R	3	2	4	2	6	5	4	6	5
Fluoroquinolones R	5	6	5	7	7	7	8	8	10
Third-gen. cephalosporins R	1	4	1	<1	1	5	2	6	12
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	14	14	9	<1	9	9	14	16
HL Gentamicin R	22	32	50	35	23	27	43	27	19
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	75	79	83	84	94	85	90	90	91
HL Gentamicin R	50	79	74	78	89	75	79	67	61
Vancomycin R	<1	<1	<1	<1	<1	3	<1	<1	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	8	9	2	15	15	26	12
Fluoroquinolones R	-	-	<1	5	2	7	19	25	22
Third-gen. cephalosporins R	-	-	8	9	3	12	17	17	40
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	27	12	9	18	13	25	<1
Ceftazidime R	-	-	18	7	7	13	7	11	<1
Carbapenems R	-	-	38	29	18	30	17	21	8
Aminoglycosides R	-	-	28	8	7	17	10	20	<1
Fluoroquinolones R	-	-	14	10	9	18	19	20	6

Due to technical problems, Estonian EARS-Net data for 2011 are based on a smaller sample than for previous years.

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	97	2	100	1	100	9	100	0	100	0	100	25	98	19
CSF	3	0	-	-	0	0	-	-	-	-	-	-	2	0
Gender														
Male	57	3	57	1	38	13	70	0	56	0	50	21	52	25
Female	43	0	43	2	62	7	30	0	44	0	50	29	48	12
Unknown	-	-	-	-	0	0	-	-	-	-	-	-	-	-
Age (years)														
0–4	7	0	6	0	3	6	13	0	-	-	5	0	2	0
5–19	3	25	2	0	2	0	4	0	-	-	2	0	4	0
20–64	65	1	49	0	41	11	39	0	52	0	48	31	43	13
65 and over	24	0	43	3	53	9	41	0	48	0	46	23	52	25
Unknown	-	-	0	0	-	-	2	0	-	-	-	-	-	-
Hospital department														
ICU	30	3	20	6	15	12	26	0	41	0	35	33	33	22
Internal med.	36	2	37	0	46	5	20	0	15	0	28	26	28	20
Surgery	1	0	5	0	6	11	9	0	7	0	7	22	2	100
Other	34	0	38	0	33	13	43	0	37	0	30	16	37	10
Unknown	-	-	-	-	0	100	2	0	-	-	-	-	-	-

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Estonia

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

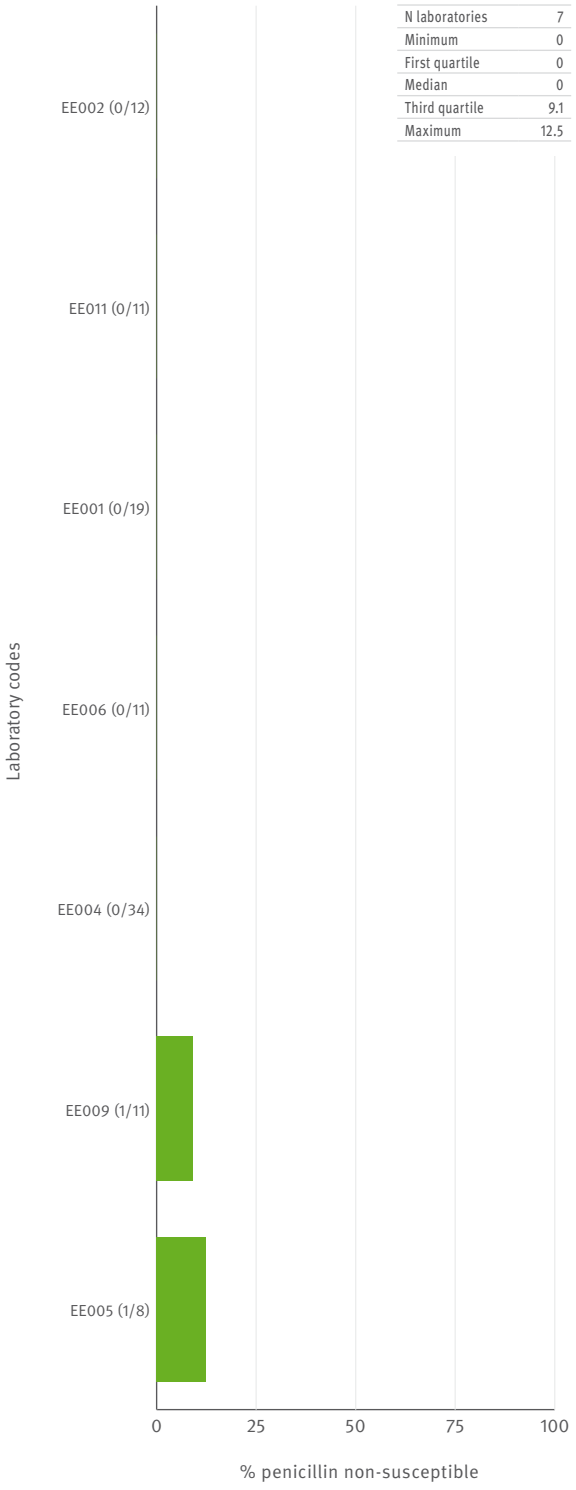


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

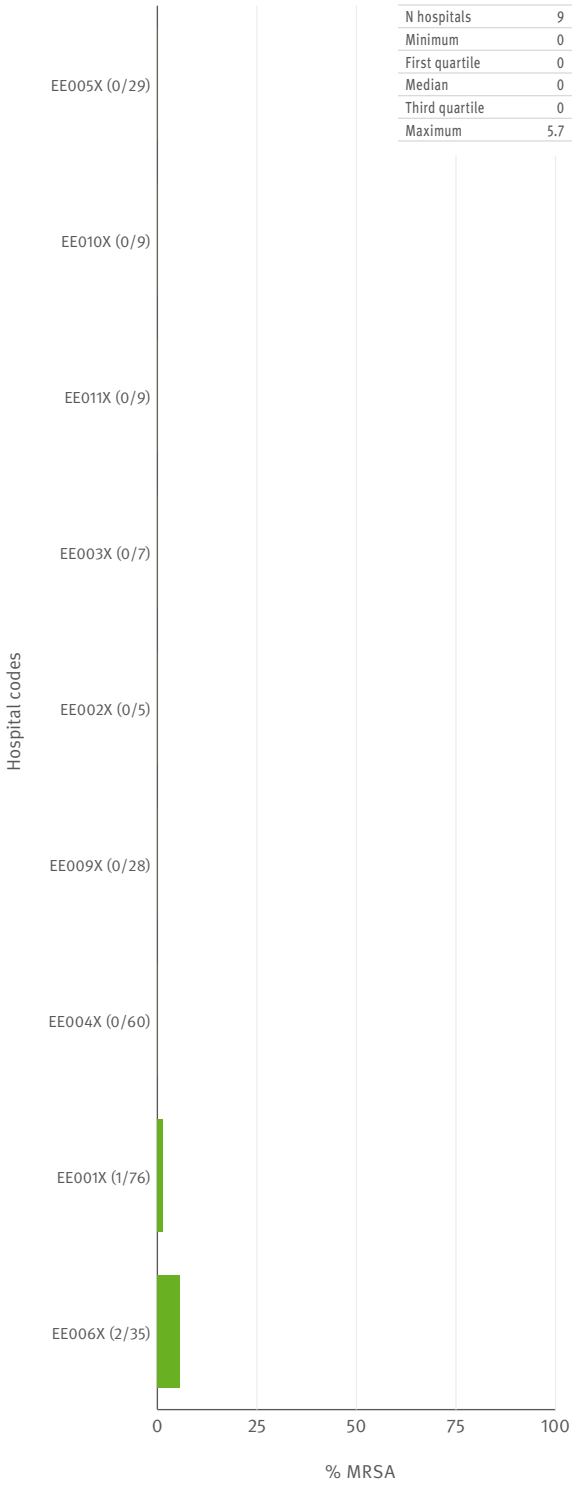


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

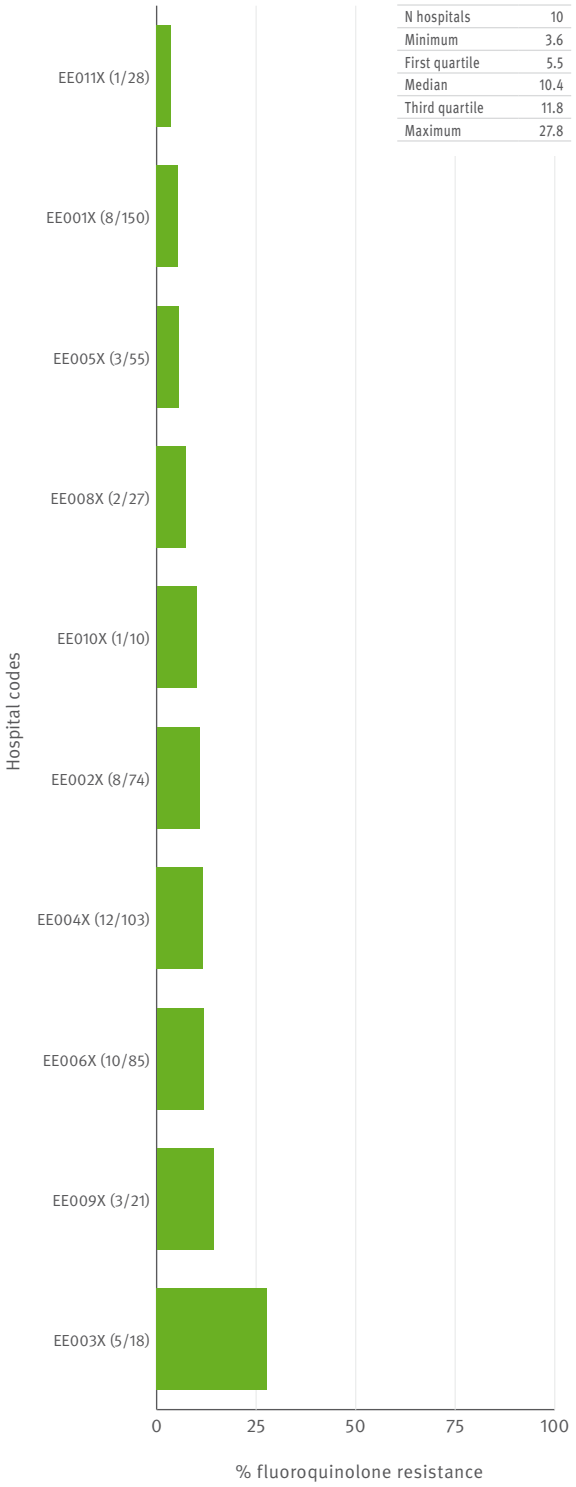


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)

Finland

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	16	517	16	727	15	1450	15	266	-	-	-	-
2004	17	548	17	883	17	1749	17	336	-	-	-	-
2005	17	543	17	790	17	1924	17	340	14	175	13	108
2006	15	501	15	894	15	1875	15	348	14	228	14	162
2007	16	547	16	814	16	1949	16	400	15	273	14	183
2008	15	643	15	923	15	2111	15	381	12	288	12	175
2009	20	688	20	978	20	2224	20	506	20	375	18	233
2010	20	622	20	1094	20	2551	20	521	20	401	20	281
2011	-	-	-	-	17	2470	16	375	17	319	16	221

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	2	<1	<1	2	1	<1	2	1	-
Penicillin RI	10	8	7	12	13	11	13	14	-
Macrolides RI	20	20	20	24	25	24	28	28	-
Staphylococcus aureus									
Oxacillin/Meticillin R	1	3	3	3	2	3	2	2	-
Escherichia coli									
Aminopenicilins R	33	33	35	36	34	35	36	34	36
Aminoglycosides R	1	2	2	2	3	4	3	4	5
Fluoroquinolones R	5	7	7	8	8	9	9	9	11
Third-gen. cephalosporins R	1	2	2	2	2	2	3	4	5
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	<1	<1	<1	2	<1	<1	<1	<1
HL Gentamicin R	39	39	27	25	22	13	-	-	-
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	79	69	78	80	87	87	87	82	89
HL Gentamicin R	4	12	1	16	19	15	-	-	-
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	3	1	<1	1	1	4	2
Fluoroquinolones R	-	-	3	4	<1	2	3	2	4
Third-gen. cephalosporins R	-	-	2	<1	1	2	1	4	3
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	8	8	7	8	7	7	14
Ceftazidime R	-	-	5	3	5	5	5	3	8
Carbapenems R	-	-	15	8	9	6	8	10	10
Aminoglycosides R	-	-	11	8	8	6	4	4	4
Fluoroquinolones R	-	-	16	17	11	15	11	11	15

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae**		*S. aureus**		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	97	14	100	2	100	10	100	0	100	0	100	4	99	10
CSF	3	10	-	-	0	0	-	-	-	-	0	0	1	29
Gender														
Male	55	15	63	2	38	14	69	0	62	0	54	5	62	12
Female	45	13	37	3	62	8	31	0	38	1	46	2	38	7
Age (years)														
0–4	16	25	4	0	2	6	7	0	2	0	1	25	1	0
5–19	3	11	4	0	1	8	1	0	1	0	1	0	2	36
20–64	44	11	39	2	27	9	24	0	32	0	26	4	29	15
65 and over	37	14	53	3	70	10	68	0	65	1	72	3	67	7
Hospital department														
ICU	0	0	2	0	0	9	0	0	2	0	1	17	2	27
Internal med.	6	3	6	1	5	8	3	0	6	0	4	4	5	15
Surgery			2	5	1	7	2	0	4	0	2	6	2	18
Other	21	8	17	2	16	11	11	0	7	0	16	4	11	2
Unknown	73	17	73	2	77	10	84	0	81	1	78	4	80	10

* Data only for 2010.
PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Finland

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

No data reported for 2011

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

No data reported for 2011

Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

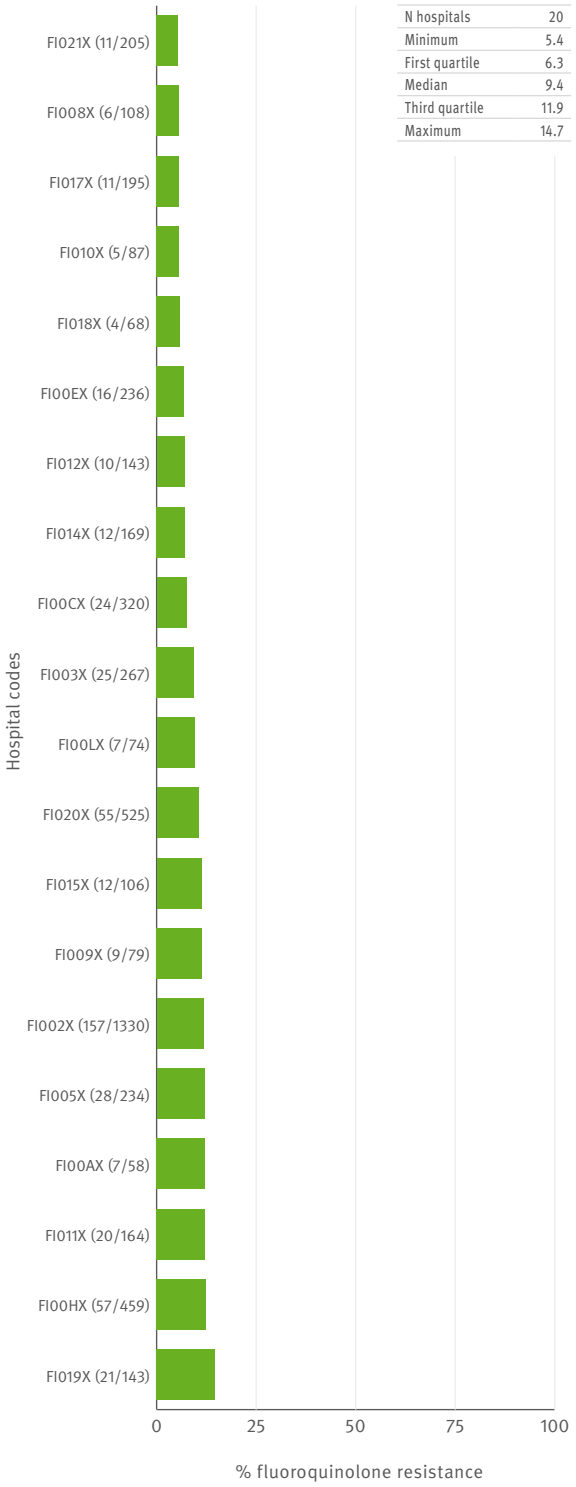
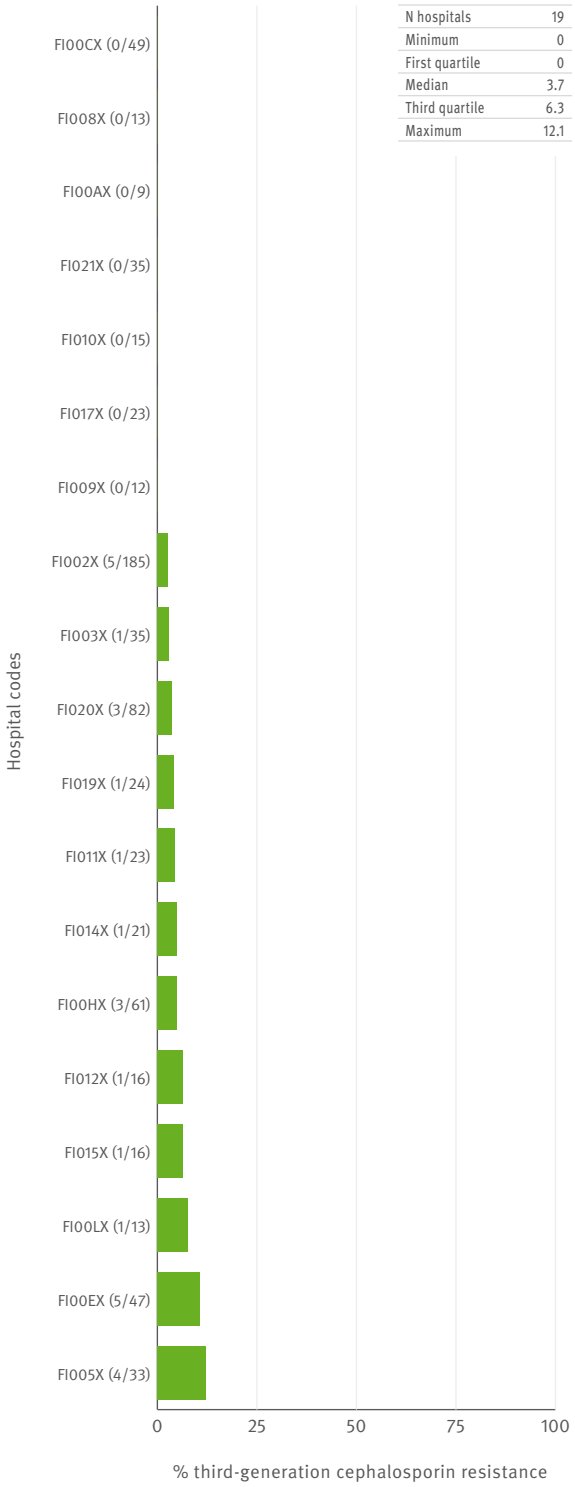


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



France

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	403	1389	21	1710	21	2266	20	468	-	-	-	-
2004	403	515	50	3355	50	5678	46	871	-	-	-	-
2005	195	632	50	3484	50	6056	47	1023	49	838	48	993
2006	97	371	50	3824	50	6718	50	1152	50	963	47	1006
2007	168	663	57	4265	57	8093	56	1545	56	1187	56	1305
2008	127	557	56	4380	56	7993	54	1555	54	1138	54	1225
2009	225	826	54	4727	54	8451	54	1969	52	1378	32	1221
2010	181	1127	56	4883	56	9028	54	1970	56	1542	36	1191
2011	255	1413	52	4740	52	8790	46	2163	52	1691	52	1634

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	-	-	5	4	4	7	6	<1	<1
Penicillin RI	43	39	36	32	34	30	27	28	24
Macrolides RI	48	45	41	36	37	31	27	30	26
Staphylococcus aureus									
Oxacillin/Meticillin R	29	29	27	27	26	24	23	22	20
Escherichia coli									
Aminopenicilins R	50	47	50	53	54	54	55	55	55
Aminoglycosides R	5	4	5	6	6	7	8	7	8
Fluoroquinolones R	9	8	11	14	15	16	19	18	18
Third-gen. cephalosporins R	<1	<1	1	2	2	4	7	7	8
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	3	1	<1	1	1	<1	1	<1	<1
HL Gentamicin R	16	17	15	16	15	18	18	18	20
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	30	56	64	69	67	68	63	78	81
HL Gentamicin R	23	21	24	30	30	30	38	41	43
Vancomycin R	<1	5	3	3	1	<1	<1	1	1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	5	7	11	17	20	18	24
Fluoroquinolones R	-	-	7	9	14	21	24	22	28
Third-gen. cephalosporins R	-	-	4	6	10	15	19	18	25
Carbapenems R	.	.	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	15	11	11	14	21	20	23
Ceftazidime R	-	-	9	6	7	8	17	13	16
Carbapenems R	-	-	14	12	14	14	17	18	20
Aminoglycosides R	-	-	22	16	18	15	19	19	21
Fluoroquinolones R	-	-	27	23	24	22	25	23	27

Demographic characteristics

Table 3: Selected details on invasive isolates from the reporting period 2009 and 2010

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	68	24	100	21	100	18	100	0	100	1	100	22	100	19
CSF	32	28	-	-	-	-	-	-	-	-	-	-	-	-
Gender														
Male	55	26	63	21	48	20	67	0	64	1	61	23	65	18
Female	45	25	35	21	51	16	32	0	35	2	37	20	34	20
Unknown	-	-	2	10	2	15	1	0	1	0	2	13	1	19
Age (years)														
0–4	21	28	4	9	2	7	5	0	2	30	2	19	2	4
5–19	9	13	3	3	1	9	1	0	1	0	1	38	2	12
20–64	36	23	40	14	34	18	36	0	45	1	47	24	49	23
65 and over	34	30	52	28	63	18	58	0	51	1	50	19	47	16
Unknown	-	-	0	0	<1	13	0	0	0	0	0	0	0	0
Hospital department														
ICU	-	-	12	20	8	23	19	0	25	2	15	40	27	31
Internal med.	-	-	35	24	28	19	30	0	30	0	30	20	23	15
Surgery	-	-	15	19	10	19	15	0	13	0	14	28	14	20
Other	-	-	36	19	53	16	34	0	29	2	38	14	33	12
Unknown	100	26	2	20	2	22	2	0	2	0	3	18	2	14

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

France

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

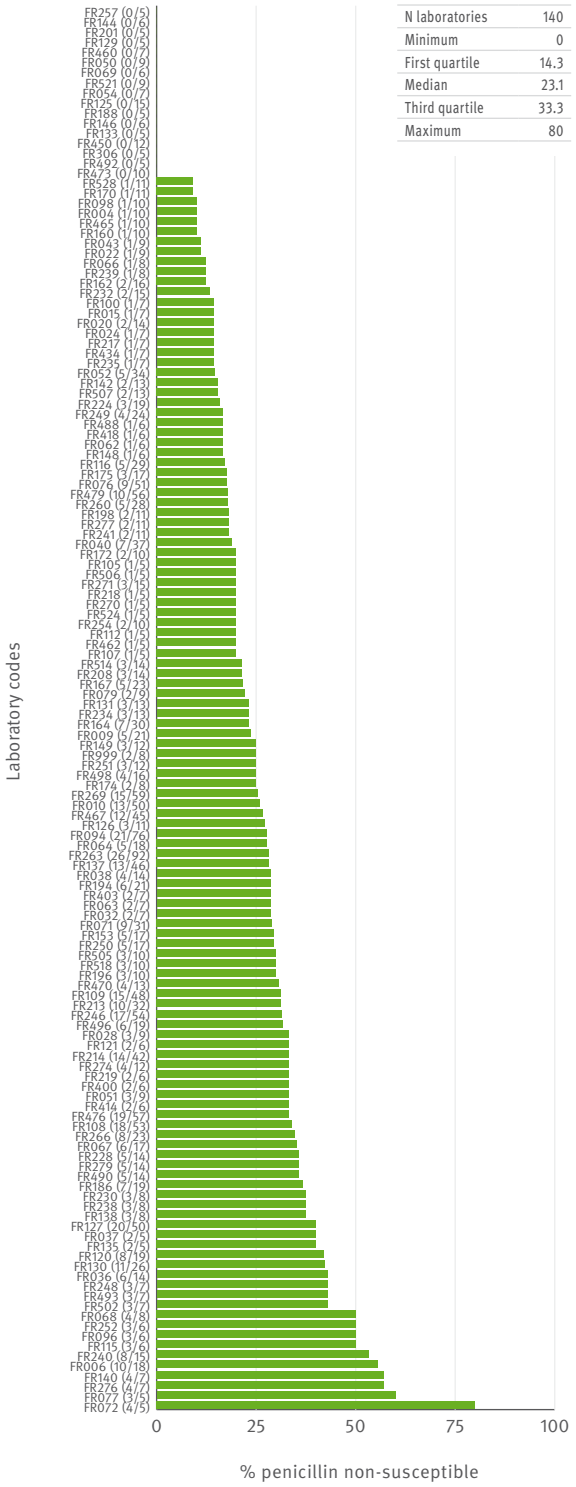


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

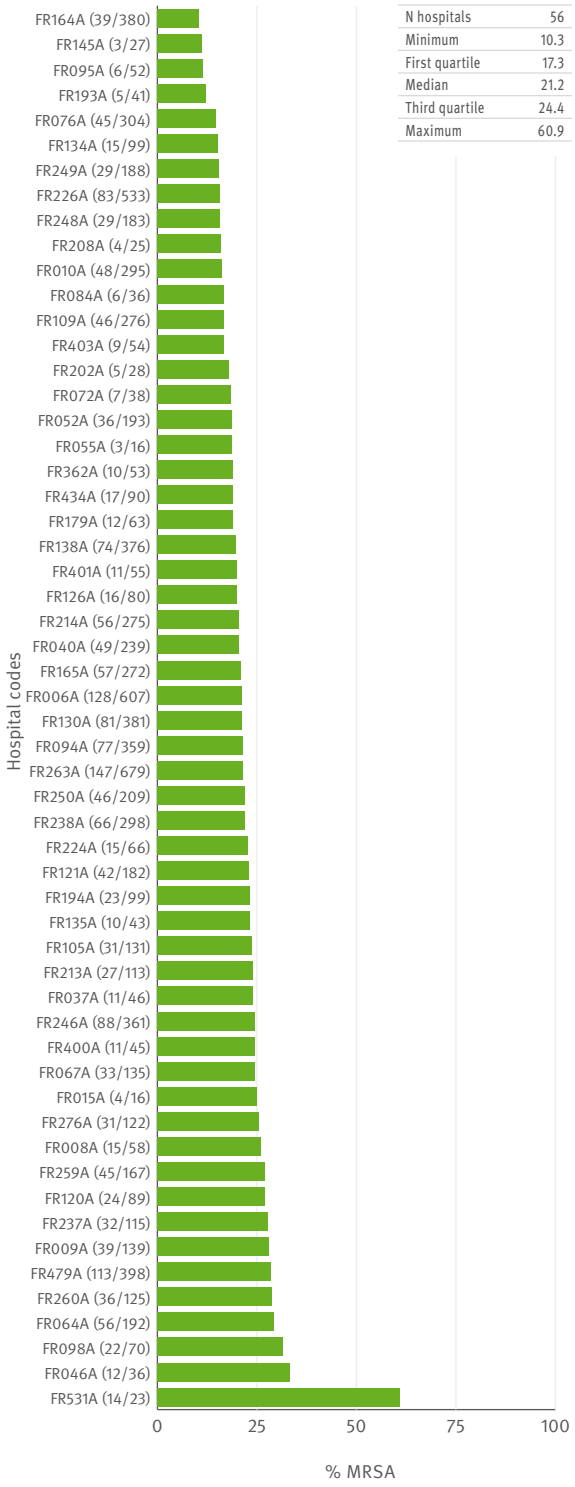


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

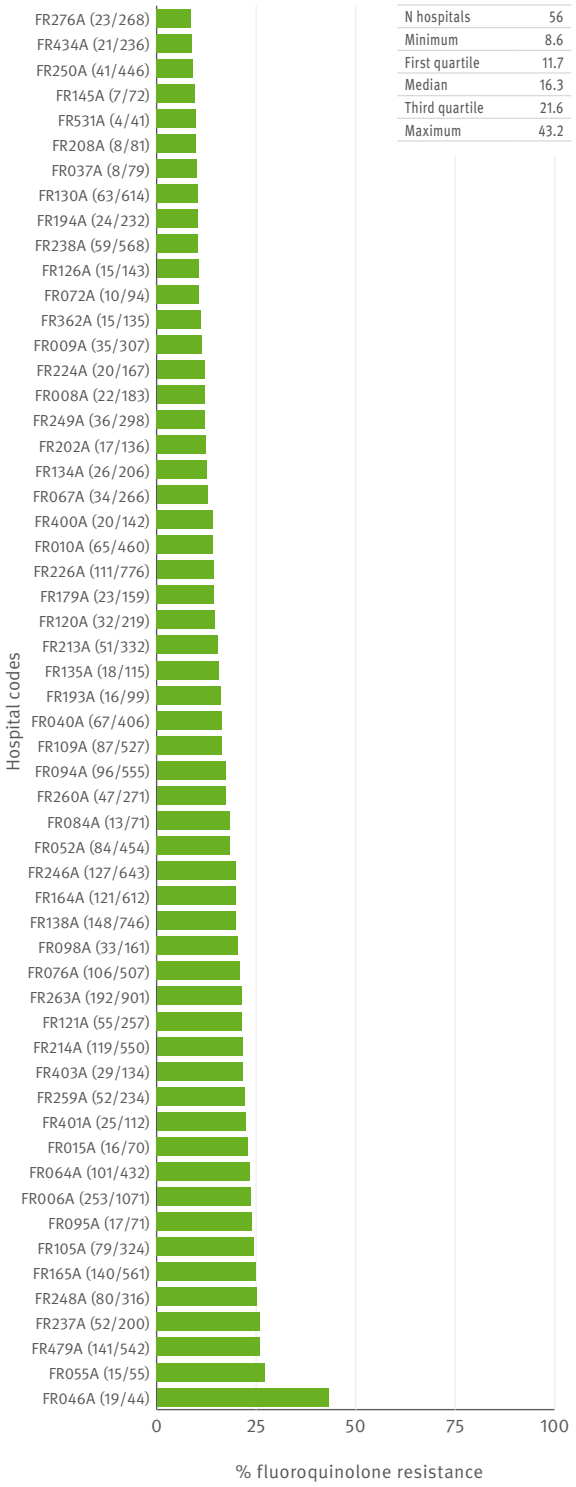
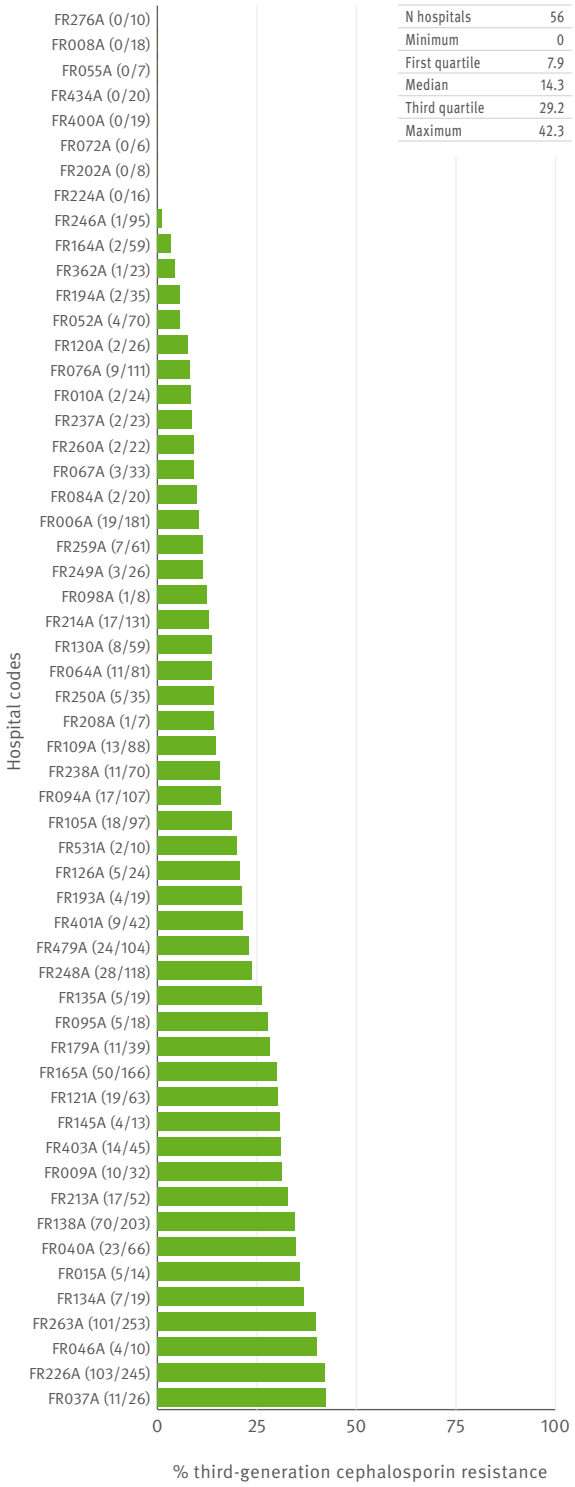


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Germany

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	17	175	20	920	19	997	17	347	-	-	-	-
2004	16	145	22	1107	22	1217	22	606	-	-	1	1
2005	15	119	17	827	17	961	17	569	12	105	12	117
2006	15	85	18	799	18	850	16	529	14	148	12	162
2007	11	75	12	853	12	977	12	648	10	173	11	197
2008	11	209	14	1090	14	1615	13	451	11	235	11	167
2009	16	346	17	1893	17	2803	17	952	15	479	16	287
2010	16	363	17	1980	17	3024	16	1009	15	478	15	315
2011	18	359	19	2388	19	3650	17	1231	17	519	17	389

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	1	<1	<1	<1	<1	<1
Penicillin RI	1	1	4	5	3	5	2	4	2
Macrolides RI	11	13	17	12	8	10	8	9	8
Staphylococcus aureus									
Oxacillin/Meticillin R	18	20	21	20	16	19	18	21	16
Escherichia coli									
Aminopenicilins R	47	55	54	60	55	55	56	54	52
Aminoglycosides R	5	4	6	10	6	7	8	9	8
Fluoroquinolones R	14	24	23	29	30	23	23	25	24
Third-gen. cephalosporins R	<1	2	2	4	8	5	8	8	8
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	7	7	3	3	7	<1	3	<1	<1
HL Gentamicin R	47	42	34	29	67	39	40	47	41
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	78	93	96	94	95	95	94	94	96
HL Gentamicin R	47	61	52	38	73	35	45	45	42
Vancomycin R	3	11	10	8	15	6	6	8	11
Klebsiella pneumoniae									
Aminoglycosides R	-	-	10	12	6	10	10	10	9
Fluoroquinolones R	-	-	6	12	9	15	15	15	14
Third-gen. cephalosporins R	-	-	7	14	6	11	13	13	13
Carbapenems R	-	-	2	<1	2	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	<1	18	17	17	9	13	16	15
Ceftazidime R	-	<1	11	12	17	8	11	8	9
Carbapenems R	-	<1	25	17	22	11	11	13	10
Aminoglycosides R	-	<1	12	18	9	10	7	10	12
Fluoroquinolones R	-	<1	23	28	28	22	17	18	18

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	94	3	100	18	100	24	100	0	100	10	99	12	99	11
CSF	6	2	-	-	<1	38	-	-	-	-	1	33	1	10
Gender														
Male	38	3	45	18	33	27	50	0	45	11	44	14	50	11
Female	32	4	28	19	40	23	25	0	31	9	32	11	23	15
Unknown	30	1	27	18	28	23	25	0	25	9	23	12	27	7
Age (years)														
0–4	7	2	2	3	1	8	2	0	2	6	3	7	2	17
5–19	1	10	2	4	1	21	1	0	1	22	1	22	1	22
20–64	40	3	28	16	21	27	27	0	35	10	27	14	28	18
65 and over	52	2	69	20	77	24	71	0	62	10	69	12	69	8
Unknown	0	0	0	0	0	0	-	-	-	-	-	-	-	-
Hospital department														
ICU	23	1	19	21	13	26	23	0	24	14	19	19	22	17
Internal med.	52	3	46	18	54	22	39	0	34	8	44	7	37	8
Surgery	3	0	12	19	7	26	11	0	6	6	9	14	10	11
Other	20	4	21	16	23	28	24	1	30	12	24	16	28	11
Unknown	3	0	2	24	3	24	2	0	5	2	3	16	3	9

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Germany

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

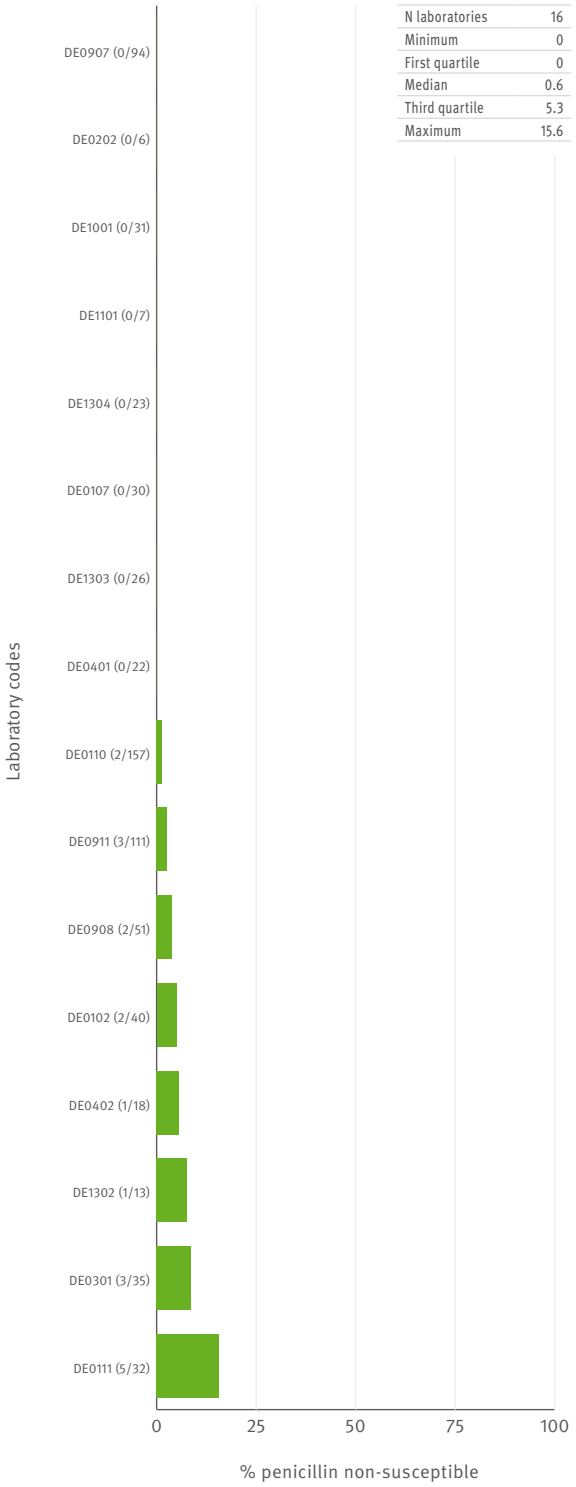
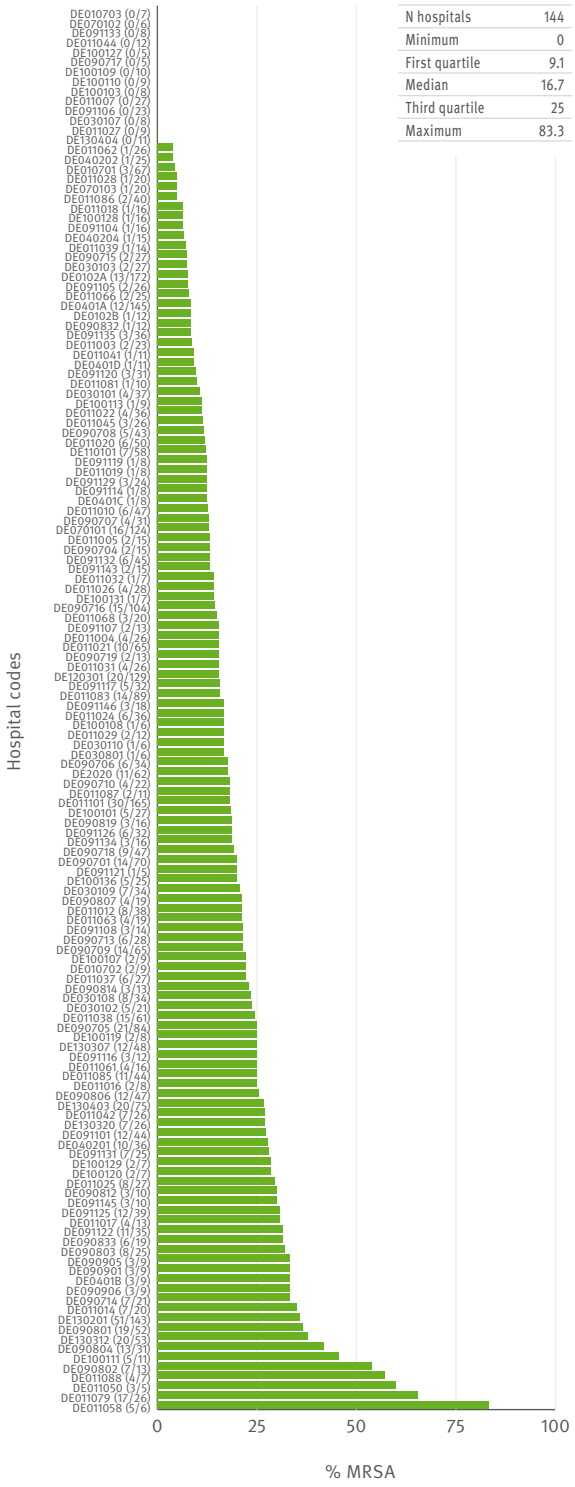


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)



Note. Individual laboratories may serve a large number of hospitals over a wide geographical area within Germany.

Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

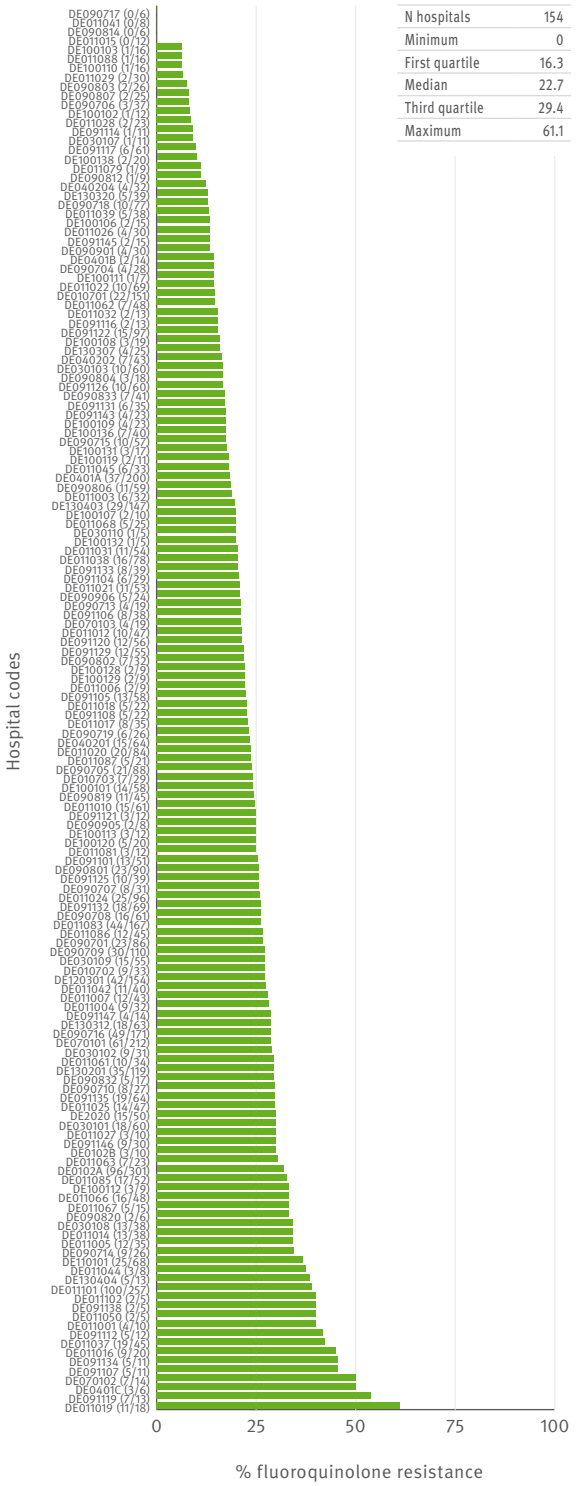
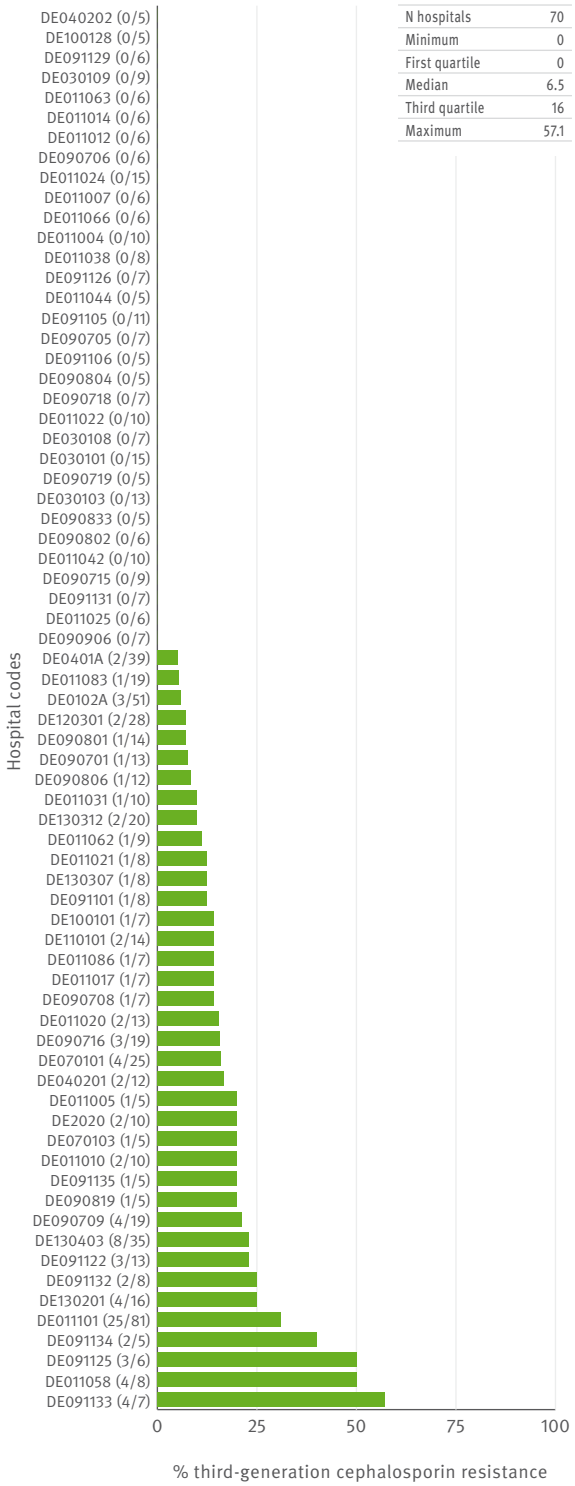


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Greece

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	-	-	34	682	35	1076	32	621	-	-	-	-
2004	-	-	35	610	39	1131	34	565	-	-	-	-
2005	-	-	35	682	35	1140	34	737	33	774	33	699
2006	-	-	42	828	41	1253	39	949	38	841	38	818
2007	-	-	41	819	43	1234	39	999	38	972	37	802
2008	-	-	46	907	44	1462	42	992	41	1093	42	920
2009	-	-	48	1025	49	1831	47	1190	47	1649	47	1123
2010	-	-	44	902	45	1549	43	1105	40	1703	42	1014
2011	-	-	39	826	37	1437	36	1122	38	1671	35	948

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	-	-	-	-	-	-	-	-	-
Penicillin RI	-	-	-	-	-	-	-	-	-
Macrolides RI	-	-	-	-	-	-	-	-	-
Staphylococcus aureus									
Oxacillin/Meticillin R	45	44	42	43	48	41	40	39	39
Escherichia coli									
Aminopenicilins R	44	46	46	46	48	50	51	52	55
Aminoglycosides R	6	6	7	7	9	15	14	16	17
Fluoroquinolones R	12	12	12	14	19	22	23	24	27
Third-gen. cephalosporins R	6	6	7	6	8	10	10	14	15
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	4	3	5	4	3	4	3	4
HL Gentamicin R	52	59	54	57	65	52	61	43	37
Vancomycin R	7	4	4	5	7	7	6	3	6
Enterococcus faecium									
Aminopenicilins RI	89	84	85	88	91	85	86	93	93
HL Gentamicin R	40	52	34	35	44	52	63	53	43
Vancomycin R	18	20	37	42	37	28	27	23	23
Klebsiella pneumoniae									
Aminoglycosides R	-	-	60	54	54	55	60	62	69
Fluoroquinolones R	-	-	54	50	55	64	66	71	72
Third-gen. cephalosporins R	-	-	61	58	62	66	69	75	76
Carbapenems R	-	-	28	33	42	37	44	49	68
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	30	39	38	34	33	39	31
Ceftazidime R	-	-	27	34	40	37	34	40	37
Carbapenems R	-	-	39	48	47	49	44	43	54
Aminoglycosides R	-	-	40	47	49	48	41	42	38
Fluoroquinolones R	-	-	39	45	50	48	45	46	39

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	-	-	100	39	100	25	100	5	100	23	97	75	97	48
CSF	-	-	-	-	<1	40	-	-	-	-	3	95	3	69
Gender														
Male	-	-	7	35	8	24	7	1	8	31	5	67	6	37
Female	-	-	5	30	10	20	5	0	6	35	4	55	5	25
Unknown	-	-	88	40	82	26	88	5	85	21	90	77	89	50
Age (years)														
0–4	-	-	5	27	5	30	8	13	5	17	5	74	5	46
5–19	-	-	-	-	<1	30	-	-	-	-	0	0	0	0
20–64	-	-	2	24	3	18	1	0	2	35	1	56	2	9
65 and over	-	-	3	23	6	28	3	0	4	30	3	61	3	31
Unknown	-	-	89	41	86	25	88	4	89	22	91	76	90	50
Hospital department														
ICU	-	-	14	50	5	31	32	10	32	27	46	92	46	59
Internal med.	-	-	71	37	77	24	51	2	47	22	36	57	38	39
Surgery	-	-	11	46	11	39	14	2	16	16	13	71	13	45
Other	-	-	2	26	4	11	2	0	4	26	2	32	1	4
Unknown	-	-	2	32	3	24	2	9	1	30	2	77	1	52

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Greece

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

No data reported

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

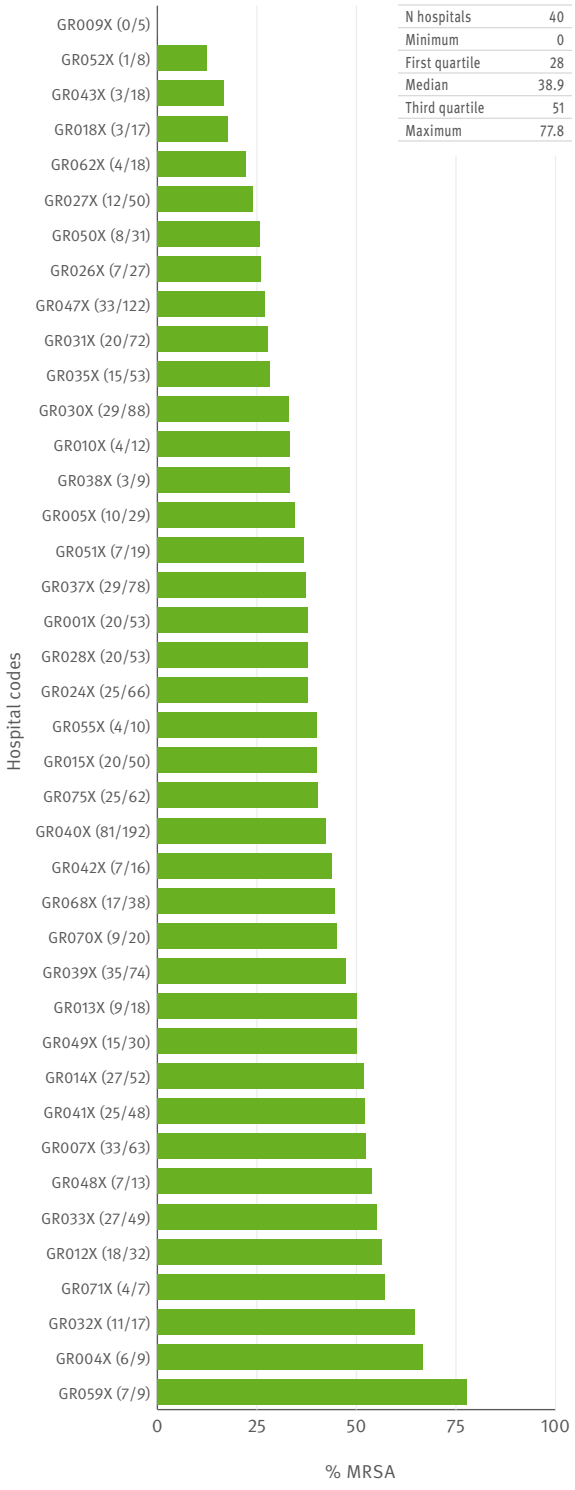


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

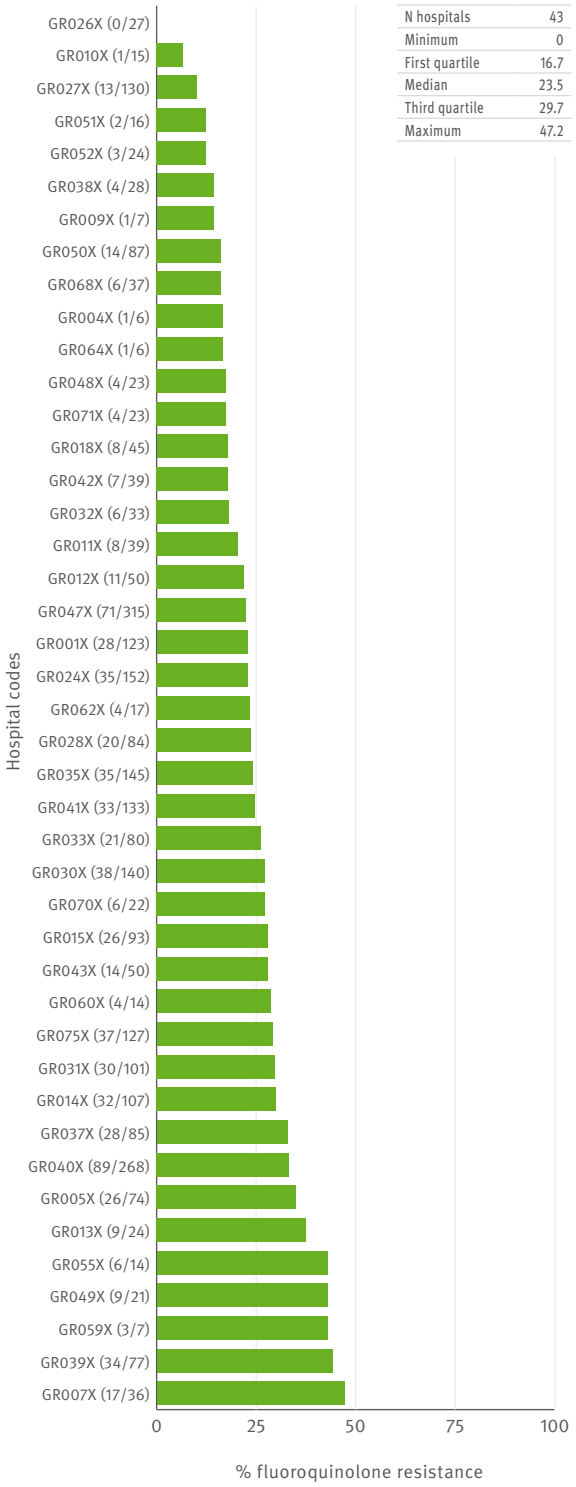
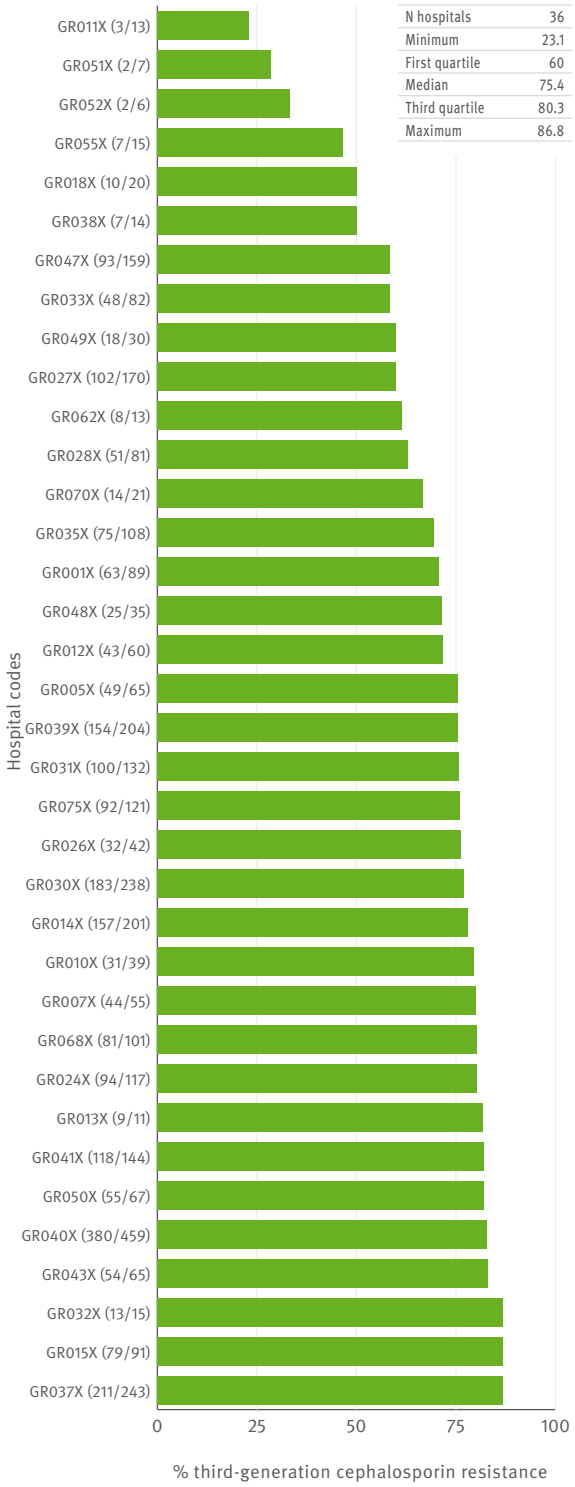


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Hungary

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	20	134	27	858	27	842	25	279	-	-	-	-
2004	26	143	30	1020	28	967	26	366	-	-	-	-
2005	23	133	28	1083	27	1046	27	476	21	314	24	507
2006	23	151	27	1127	26	1135	25	453	24	302	25	546
2007	22	146	26	1199	25	1179	26	400	23	322	24	518
2008	22	166	26	1181	25	1057	21	428	23	369	25	513
2009	22	143	26	1068	25	1057	27	444	24	361	25	518
2010	27	140	30	1224	29	1385	29	591	29	514	28	636
2011	27	139	28	1156	30	1227	28	582	27	432	29	606

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	3	<1	4	1	5	8	3	6	6
Penicillin RI	24	16	21	18	23	27	12	15	12
Macrolides RI	25	25	32	19	36	32	19	24	15
Staphylococcus aureus									
Oxacillin/Meticillin R	15	17	20	25	23	23	29	30	26
Escherichia coli									
Aminopenicilins R	49	55	51	53	54	59	60	65	65
Aminoglycosides R	8	10	9	12	11	13	16	21	15
Fluoroquinolones R	15	19	22	27	26	26	30	37	31
Third-gen. cephalosporins R	<1	3	4	5	5	9	13	19	15
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	2	1	3	2	3	2	1	1
HL Gentamicin R	87	57	43	47	48	53	51	51	49
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	91	95	91	88	88	96	97	97	95
HL Gentamicin R	96	80	64	67	53	62	70	62	45
Vancomycin R	<1	<1	<1	<1	<1	3	1	2	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	26	20	29	36	40	48	53
Fluoroquinolones R	-	-	21	13	22	33	33	43	51
Third-gen. cephalosporins R	-	-	28	20	25	35	38	46	53
Carbapenems R	.	.	<1	<1	<1	<1	<1	5	2
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	10	9	11	13	19	14	11
Ceftazidime R	-	-	10	8	9	11	12	11	12
Carbapenems R	-	-	18	16	19	26	27	25	21
Aminoglycosides R	-	-	32	23	26	26	29	29	18
Fluoroquinolones R	-	-	28	21	24	26	27	27	20

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	67	11	100	28	100	34	100	0	100	1	98	49	97	23
CSF	33	18	-	-	-	-	-	-	-	-	2	57	3	19
Gender														
Male	54	10	57	28	43	36	57	0	56	2	56	54	57	25
Female	44	18	41	28	56	33	41	0	42	0	43	42	40	21
Unknown	2	0	2	33	1	19	2	0	2	0	1	86	3	16
Age (years)														
0–4	9	20	1	6	3	12	4	0	4	0	7	48	5	18
5–19	6	18	2	5	1	22	1	0	1	0	1	60	2	12
20–64	48	15	45	26	38	33	39	0	46	1	43	50	49	27
65 and over	36	8	52	31	58	36	57	0	48	2	48	48	45	20
Unknown	<1	100	-	-	-	-	-	-	-	-	-	-	-	-
Hospital department														
ICU	32	15	21	39	14	32	38	0	43	3	30	51	43	30
Internal med.	17	13	22	29	24	32	16	0	13	0	14	34	11	13
Surgery	1	0	10	35	5	28	7	0	5	0	9	63	11	15
Other	41	12	35	21	42	32	25	0	25	0	31	47	23	19
Unknown	9	20	12	25	14	46	14	0	14	0	17	56	13	24

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Hungary

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

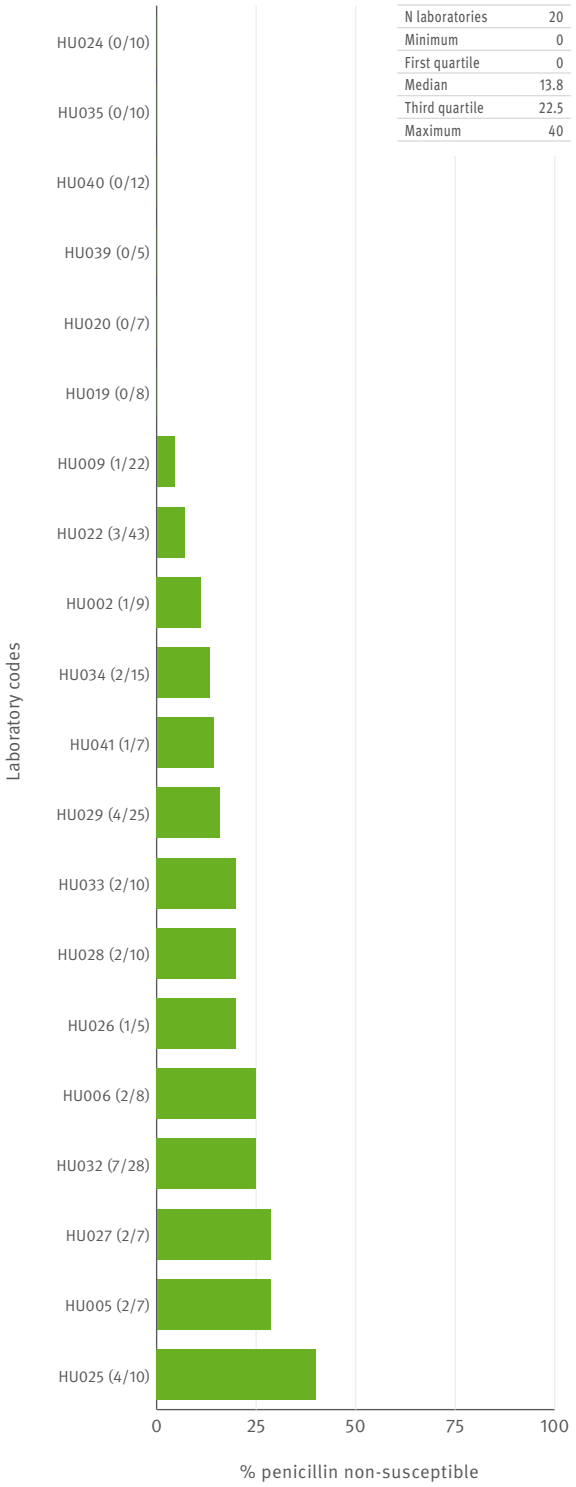


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

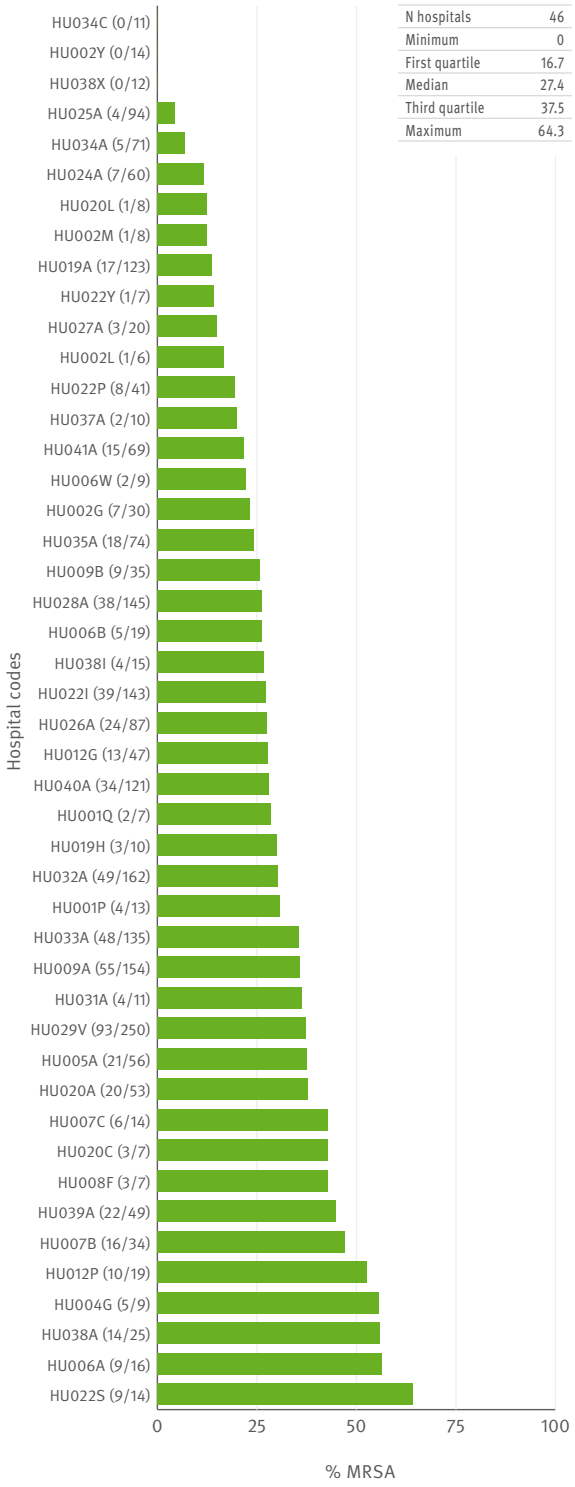


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

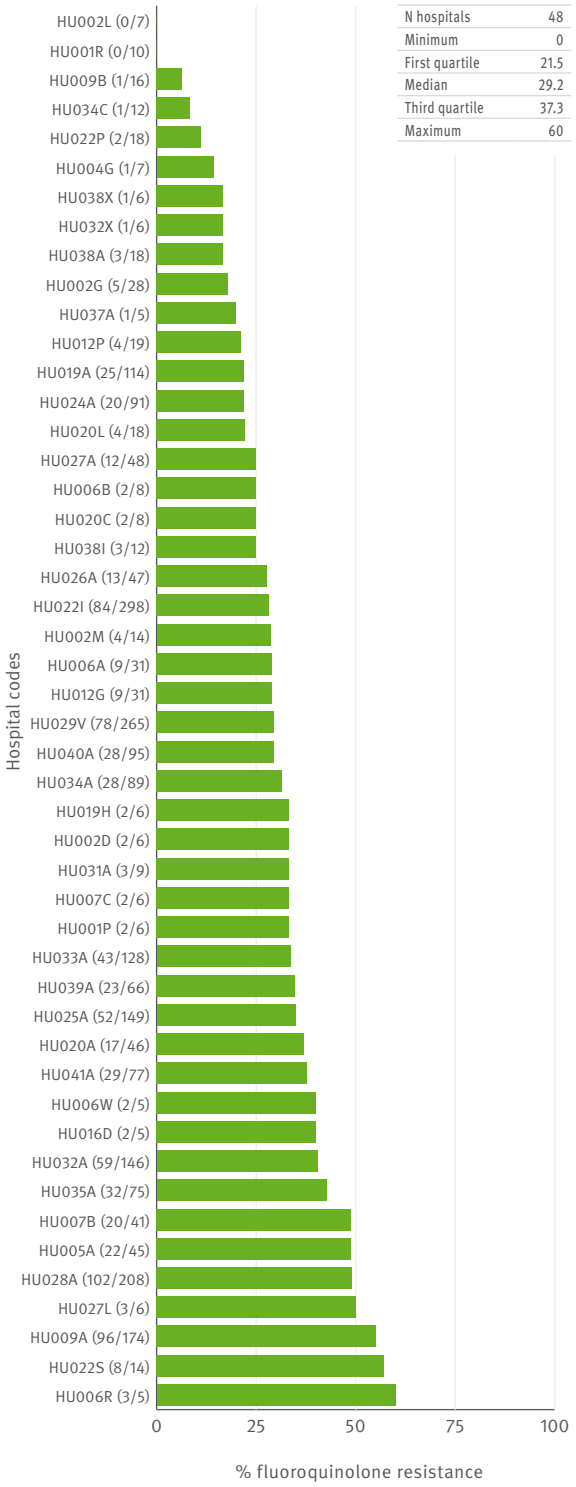
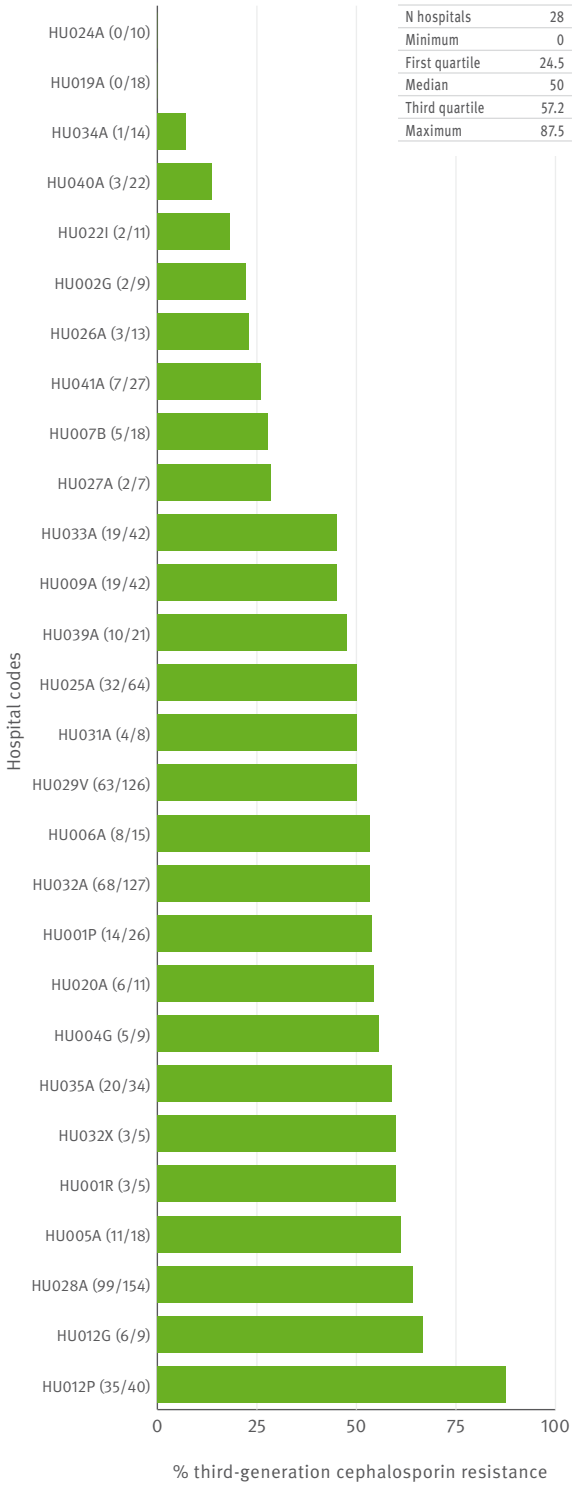


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Iceland

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	2	35	2	64	2	100	2	22	-	-	-	-
2004	2	54	2	55	2	119	1	27	-	-	-	-
2005	2	37	2	78	2	130	2	31	2	22	1	13
2006	2	52	2	57	2	130	2	40	2	13	1	9
2007	2	42	2	65	2	105	1	29	2	27	1	11
2008	2	46	2	63	2	123	2	17	1	24	2	7
2009	2	35	2	59	2	111	2	51	2	27	2	16
2010	2	37	2	65	2	104	2	31	2	27	2	12
2011	2	32	2	71	2	130	2	32	2	26	2	17

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	2	<1	<1	2	<1	<1	3	6
Penicillin RI	9	17	8	6	7	9	<1	5	9
Macrolides RI	20	8	17	10	17	22	3	11	22
Staphylococcus aureus									
Oxacillin/Meticillin R	<1	<1	<1	<1	<1	2	<1	2	3
Escherichia coli									
Aminopenicilins R	42	43	38	45	46	44	50	46	48
Aminoglycosides R	2	<1	<1	7	6	7	7	3	6
Fluoroquinolones R	6	2	3	12	17	6	7	11	14
Third-gen. cephalosporins R	1	<1	<1	<1	2	<1	2	4	6
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	-
Enterococcus faecalis									
Aminopenicilins RI	<1	<1	<1	7	<1	<1	<1	<1	<1
HL Gentamicin R	<1	5	<1	3	13	30	15	13	<1
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	57	63	80	56	57	43	68	38	69
HL Gentamicin R	<1	13	<1	14	14	43	36	13	15
Vancomycin R	<1	<1	<1	<1	<1	<1	8	6	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	<1	<1	<1	4	<1	<1	<1
Fluoroquinolones R	-	-	<1	<1	<1	8	<1	<1	4
Third-gen. cephalosporins R	-	-	<1	<1	<1	4	<1	4	8
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	-
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	8	<1	<1	<1	13	8	6
Ceftazidime R	-	-	8	<1	<1	<1	6	8	6
Carbapenems R	-	-	8	<1	<1	<1	<1	<1	6
Aminoglycosides R	-	-	<1	<1	<1	<1	<1	<1	<1
Fluoroquinolones R	-	-	<1	<1	<1	<1	13	17	6

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	90	5	100	2	100	13	100	0	100	3	100	6	100	3
CSF	10	29	-	-	-	-	-	-	-	-	-	-	-	-
Gender														
Male	65	7	63	2	45	15	50	0	66	5	57	7	72	5
Female	35	8	38	2	55	10	50	0	34	0	43	4	28	0
Age (years)														
0–4	12	38	5	0	2	0	3	0	3	0	-	-	3	0
5–19	3	0	4	0	1	0	-	-	3	0	-	-		
20–64	43	3	44	3	37	14	35	0	48	0	51	4	52	0
65 and over	42	3	46	2	60	12	62	0	45	8	49	8	45	8
Hospital department														
ICU	6	0	3	0	<1	100	9	0	21	0	-	-	10	0
Internal med.	14	10	28	0	24	10	24	0	10	0	17	0	28	13
Surgery	-	-	1	0	3	33	12	0	10	0	2	0	7	0
Other	80	7	66	3	73	12	53	0	59	6	77	7	55	0
Unknown	-	-	1	0	-	-	3	0	-	-	4	0	-	-

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Iceland

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

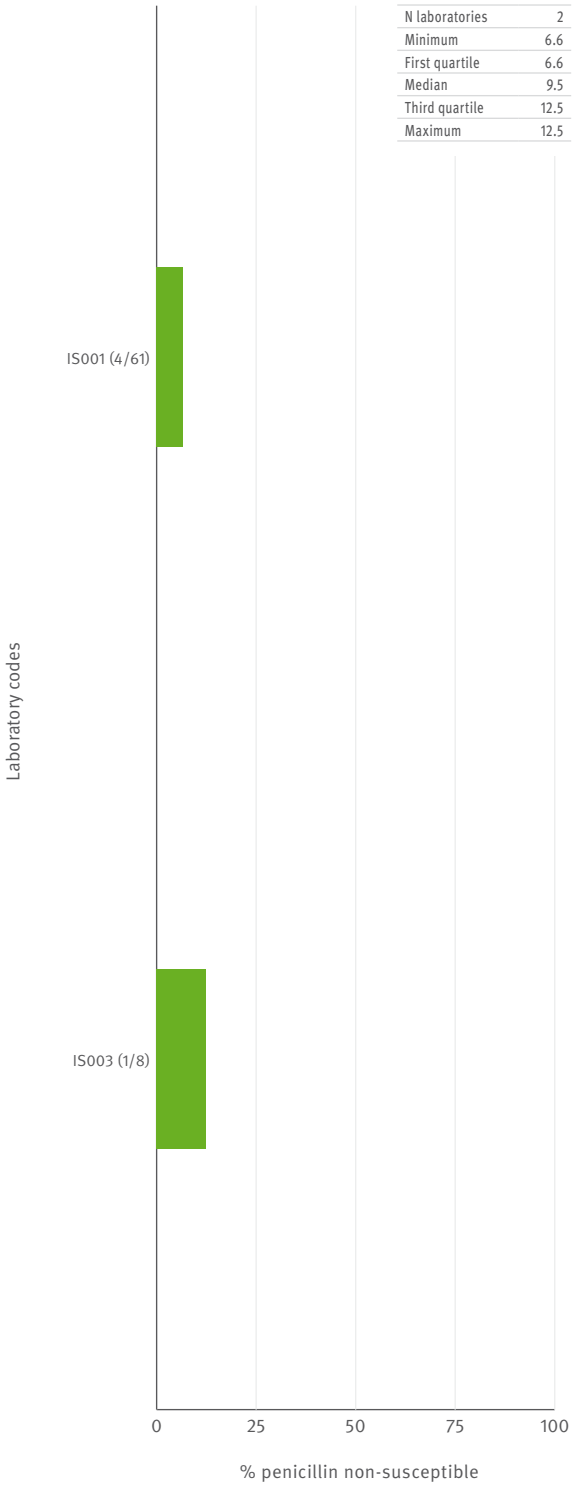


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

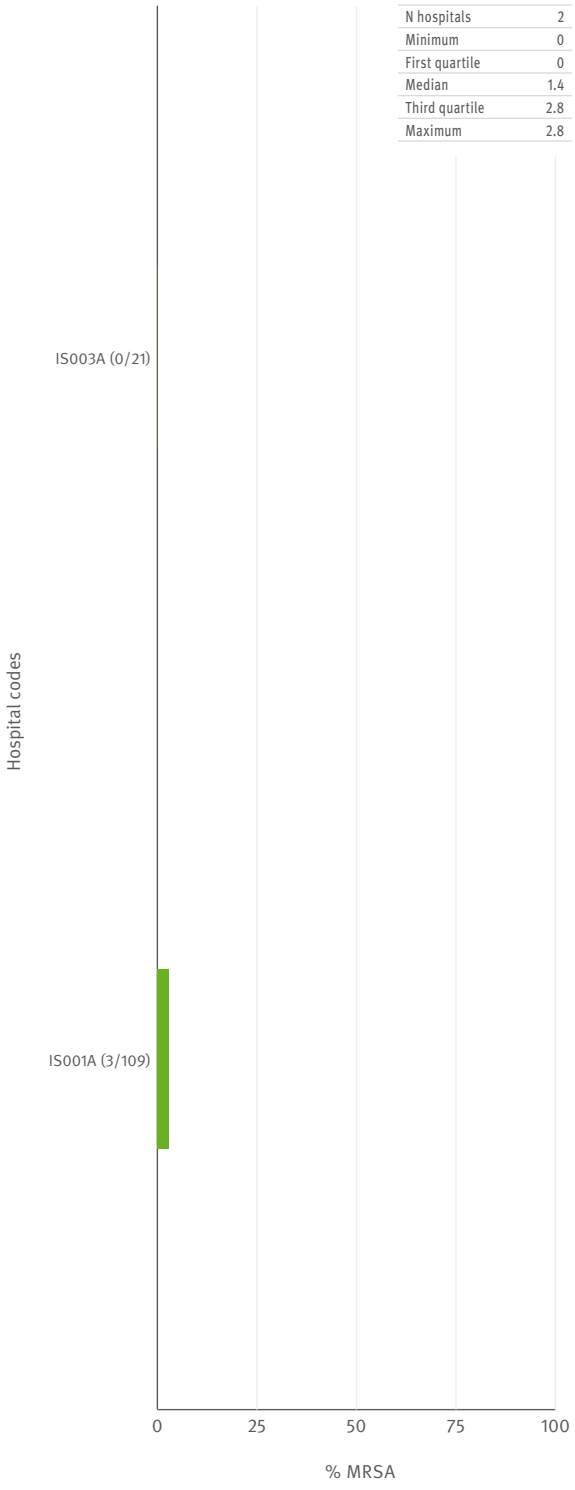


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

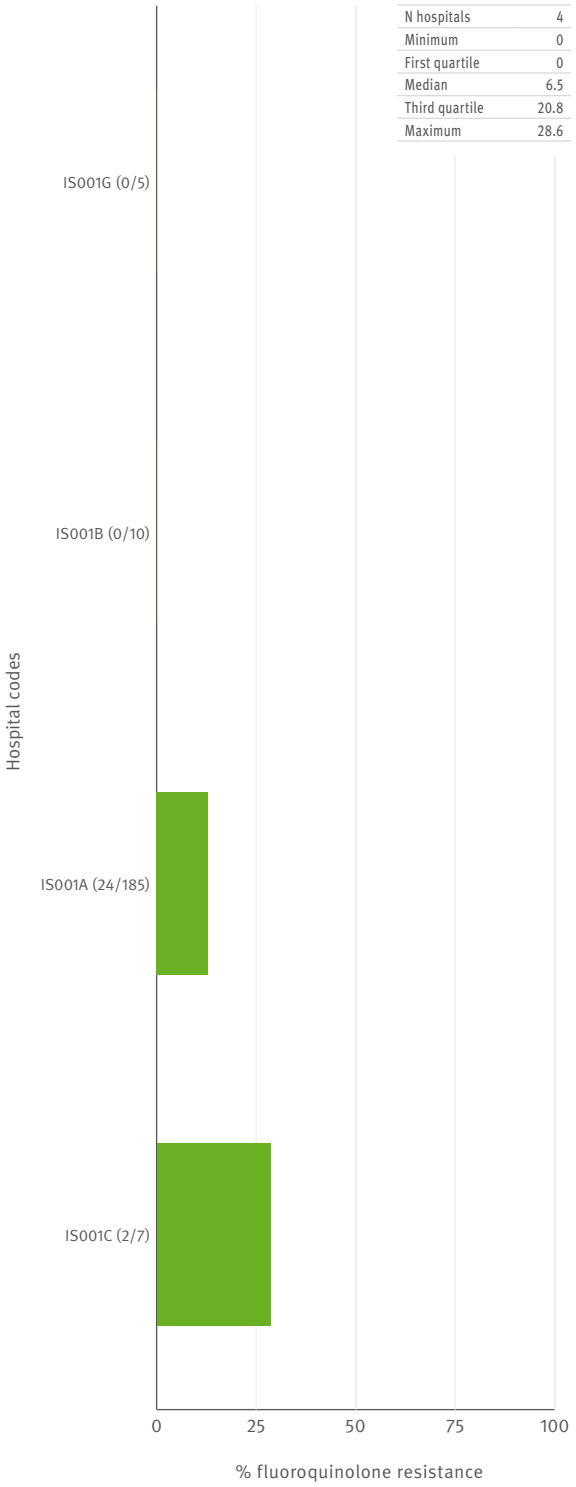
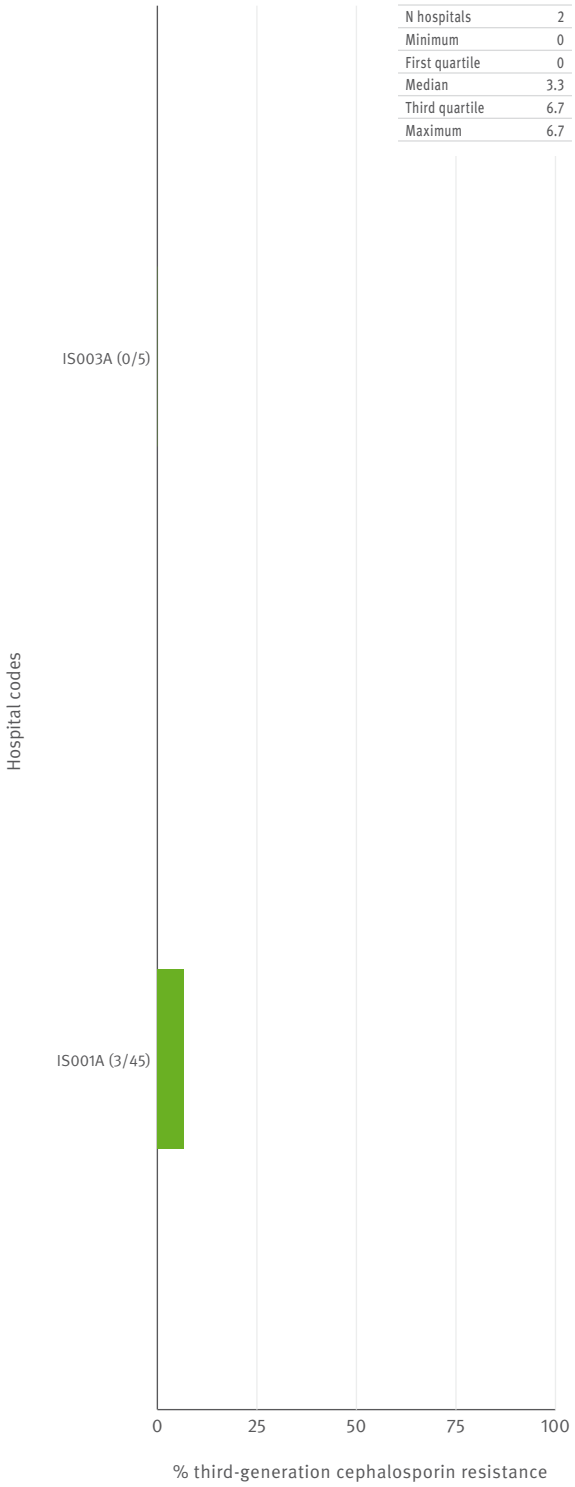


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Ireland

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	24	363	26	1 108	26	978	21	348	-	-	-	-
2004	28	399	38	1 286	37	1 235	29	418	-	-	-	-
2005	31	397	38	1 360	39	1 424	33	502	15	42	11	29
2006	32	406	38	1 347	39	1 638	32	550	28	211	23	128
2007	33	435	41	1 332	42	1 750	37	598	31	237	29	172
2008	35	442	38	1 242	41	1 875	37	685	33	307	29	191
2009	34	356	41	1 261	41	2 012	38	671	37	316	30	236
2010	32	310	39	1 207	40	2 121	38	670	34	318	30	219
2011	32	324	39	1 057	38	2 167	36	608	34	304	28	181

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	3	3	3	3	6	6	6	5	6
Penicillin RI	12	10	11	16	17	23	20	18	19
Macrolides RI	12	14	12	16	17	17	17	16	18
Staphylococcus aureus									
Oxacillin/Meticillin R	42	41	42	42	38	33	27	24	24
Escherichia coli									
Aminopenicilins R	61	65	67	69	65	67	66	67	70
Aminoglycosides R	4	5	7	7	10	9	9	10	10
Fluoroquinolones R	10	12	17	21	21	23	22	23	23
Third-gen. cephalosporins R	2	2	4	4	5	6	6	8	9
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	5	<1	4	5	2	<1	3	2	<1
HL Gentamicin R	32	42	42	43	38	31	34	29	30
Vancomycin R	<1	1	3	3	3	3	<1	<1	4
Enterococcus faecium									
Aminopenicilins RI	91	96	93	94	93	95	93	96	96
HL Gentamicin R	54	56	52	44	36	27	38	39	36
Vancomycin R	19	22	31	36	33	35	38	39	35
Klebsiella pneumoniae									
Aminoglycosides R	-	-	5	9	10	9	11	7	8
Fluoroquinolones R	-	-	3	16	17	11	11	8	9
Third-gen. cephalosporins R	-	-	7	9	8	11	11	8	8
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	7	7	6	5	4	8	3
Ceftazidime R	-	-	10	6	5	4	6	6	4
Carbapenems R	-	-	11	9	9	6	8	6	6
Aminoglycosides R	-	-	7	9	10	6	6	5	4
Fluoroquinolones R	-	-	14	17	18	16	9	11	6

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	97	19	100	24	100	23	100	2	100	37	100	8	99	6
CSF	3	13	-	-	<1	14	-	-	-	-	0	0	1	0
Gender														
Male	54	19	63	23	46	27	61	2	57	36	56	10	60	5
Female	46	19	37	25	54	19	39	1	43	38	44	6	40	9
Unknown	-	-	-	-	-	-	<1	100	-	-	-	-	-	-
Age (years)														
0–4	9	16	8	7	3	7	9	0	2	8	2	20	3	8
5–19	3	24	4	11	1	9	1	0	2	14	1	0	2	14
20–64	39	16	38	18	31	19	34	3	41	46	45	6	36	10
65 and over	49	22	50	32	65	26	56	2	55	32	51	9	59	4
Unknown	-	-	-	-	0	0	-	-	-	-	-	-	-	-
Hospital department														
ICU	3	14	3	31	2	20	5	4	8	37	3	10	4	6
Internal med.	10	21	11	37	12	27	10	2	8	35	8	8	11	2
Surgery	1	17	5	32	5	25	5	0	5	33	4	5	7	4
Other	30	17	22	15	25	20	19	1	9	28	20	2	17	12
Unknown	56	20	59	24	56	23	60	2	70	39	65	10	60	6

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Ireland

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

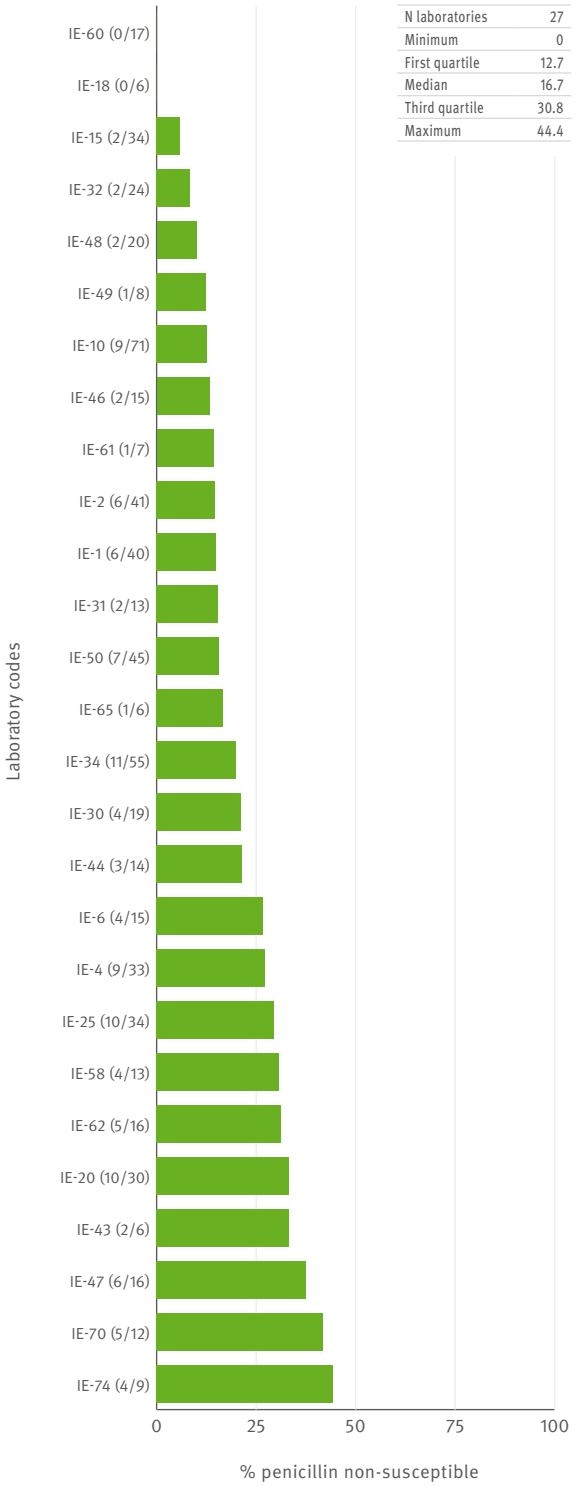


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

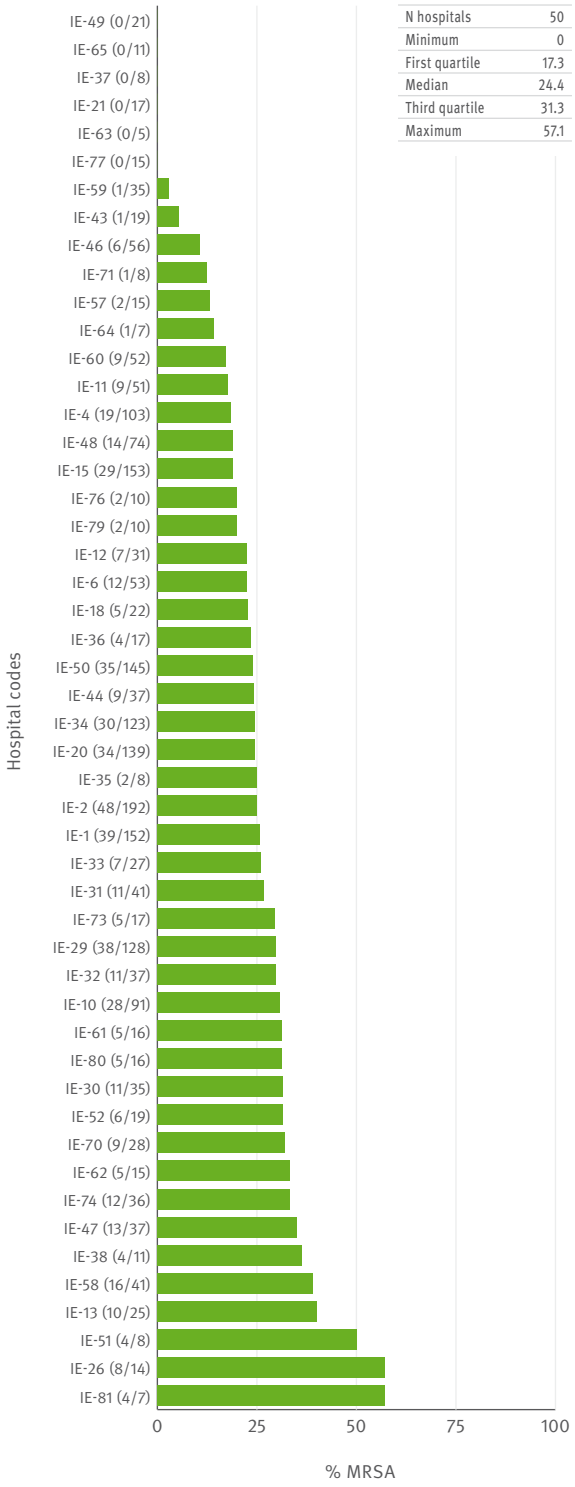


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

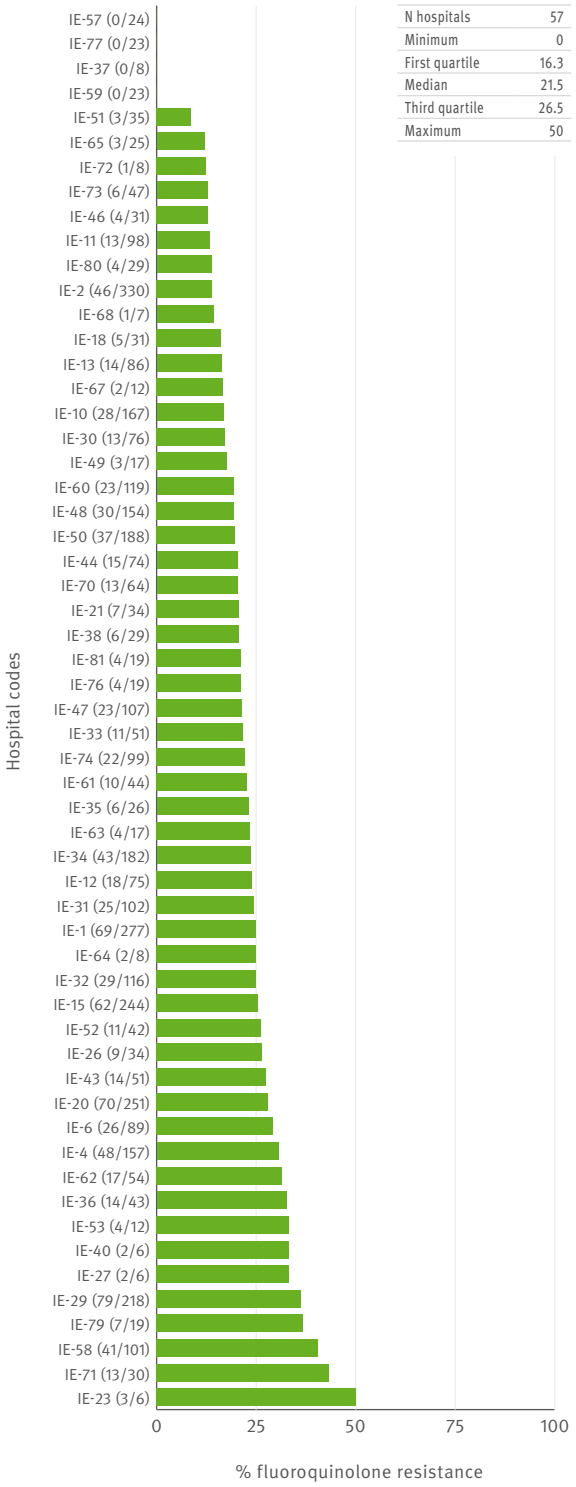
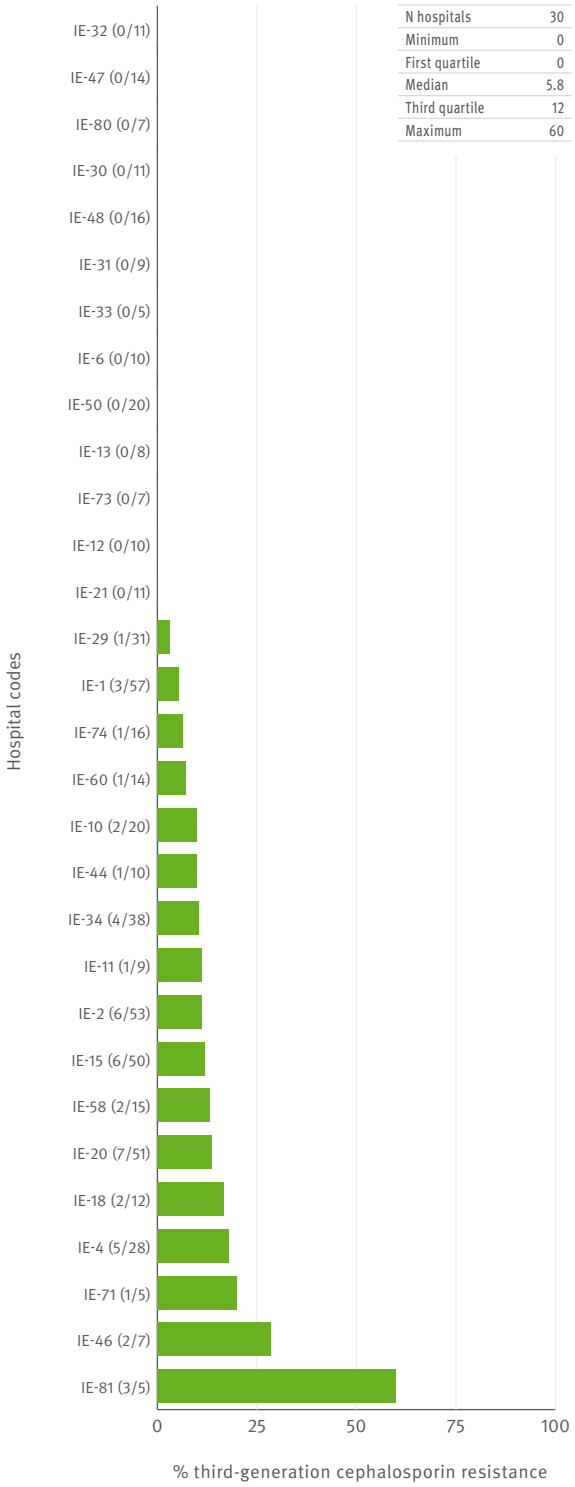


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Italy

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	44	293	46	1480	17	923	44	634	-	-	-	-
2004	37	271	42	1225	14	645	40	576	-	-	-	-
2005	38	331	41	1479	16	1195	40	714	38	344	-	-
2006	34	269	38	1164	13	910	35	650	32	321	12	183
2007	34	298	38	1167	14	1052	36	656	37	391	10	185
2008	27	194	30	939	14	957	31	580	27	331	11	168
2009	21	216	23	987	9	863	22	509	22	313	10	195
2010	33	323	35	1886	23	2623	35	1106	34	739	23	517
2011	29	294	31	1372	21	2098	31	841	30	688	21	355

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	5	5	5	<1	4	3	3	5	6
Penicillin RI	13	14	9	7	15	10	6	9	7
Macrolides RI	37	29	31	33	31	26	21	29	27
Staphylococcus aureus									
Oxacillin/Meticillin R	39	40	37	38	33	34	37	37	38
Escherichia coli									
Aminopenicilins R	52	53	55	56	58	62	63	64	67
Aminoglycosides R	10	9	11	8	14	14	13	15	18
Fluoroquinolones R	25	28	28	27	32	38	36	39	41
Third-gen. cephalosporins R	6	5	8	7	11	16	17	21	20
Carbapenems R	-	-	-	-	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	4	4	4	4	13	20	13	11
HL Gentamicin R	39	36	38	38	39	47	49	50	50
Vancomycin R	2	2	3	3	2	2	3	2	3
Enterococcus faecium									
Aminopenicilins RI	80	78	77	86	73	64	60	70	83
HL Gentamicin R	44	39	36	48	53	49	52	59	54
Vancomycin R	24	21	19	18	11	6	4	4	4
Klebsiella pneumoniae									
Aminoglycosides R	-	-	8	26	25	28	19	29	35
Fluoroquinolones R	-	-	11	23	27	28	20	39	46
Third-gen. cephalosporins R	-	-	20	33	35	39	37	47	46
Carbapenems R	-	-	-	1	1	2	1	15	27
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	23	20	20	24	21	22
Ceftazidime R	-	-	-	20	25	24	16	18	16
Carbapenems R	-	-	-	21	27	33	31	22	21
Aminoglycosides R	-	-	-	30	27	30	36	23	20
Fluoroquinolones R	-	-	-	36	35	36	42	31	26

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	88	8	100	37	100	40	100	2	100	4	98	46	98	21
CSF	12	8	-	-	<1	42	-	-	-	-	2	54	2	21
Gender														
Male	51	6	56	39	47	46	59	3	60	4	55	49	60	21
Female	46	10	39	36	48	34	35	2	36	4	41	42	35	21
Unknown	3	17	4	30	6	41	6	0	4	4	4	52	5	24
Age (years)														
0–4	6	8	2	28	1	11	5	0	3	0	3	46	2	20
5–19	3	0	1	17	1	35	1	0	2	0	1	50	1	50
20–64	26	5	21	26	17	38	16	3	20	4	22	46	21	31
65 and over	48	6	46	41	44	40	46	3	45	3	42	51	38	14
Unknown	17	22	29	41	37	41	32	3	31	6	32	40	38	23
Hospital department														
ICU	6	13	9	43	5	44	18	2	18	5	20	62	22	34
Internal med.	33	5	45	40	41	39	40	3	34	5	35	44	32	19
Surgery	4	12	13	42	16	42	14	3	15	2	16	36	16	14
Other	50	10	22	30	33	39	18	3	25	2	20	35	24	17
Unknown	6	4	10	30	5	41	10	3	8	6	9	65	5	27

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Italy

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

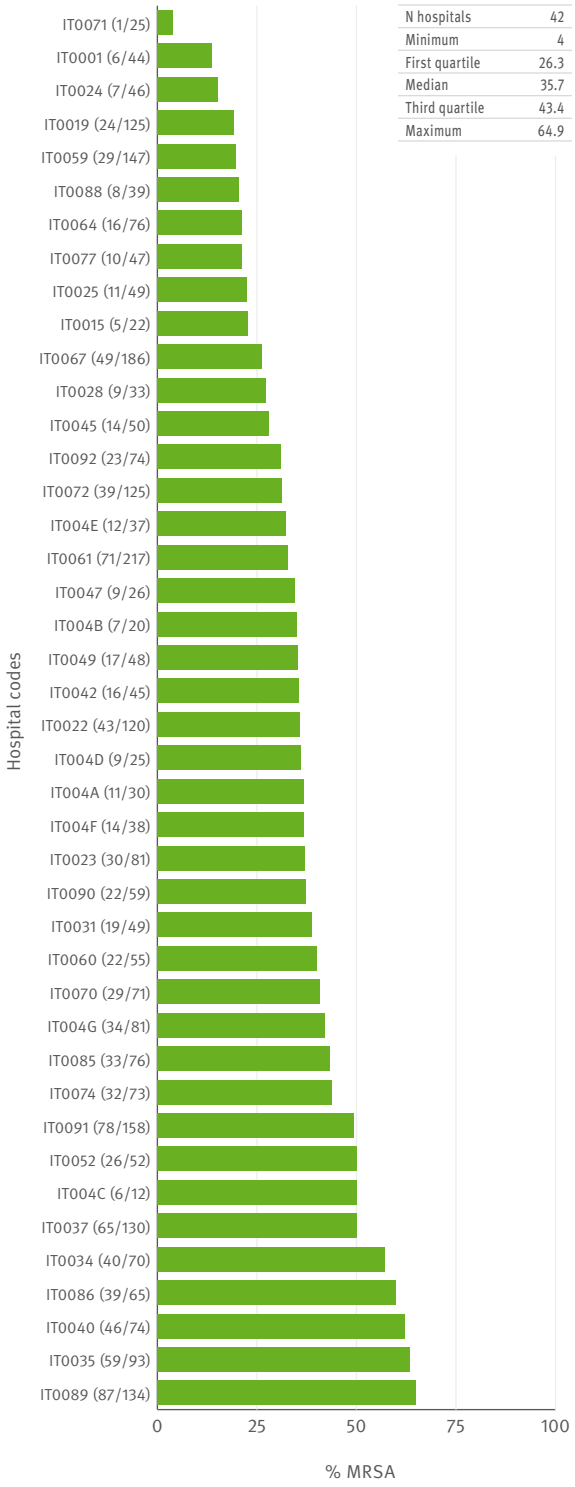


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

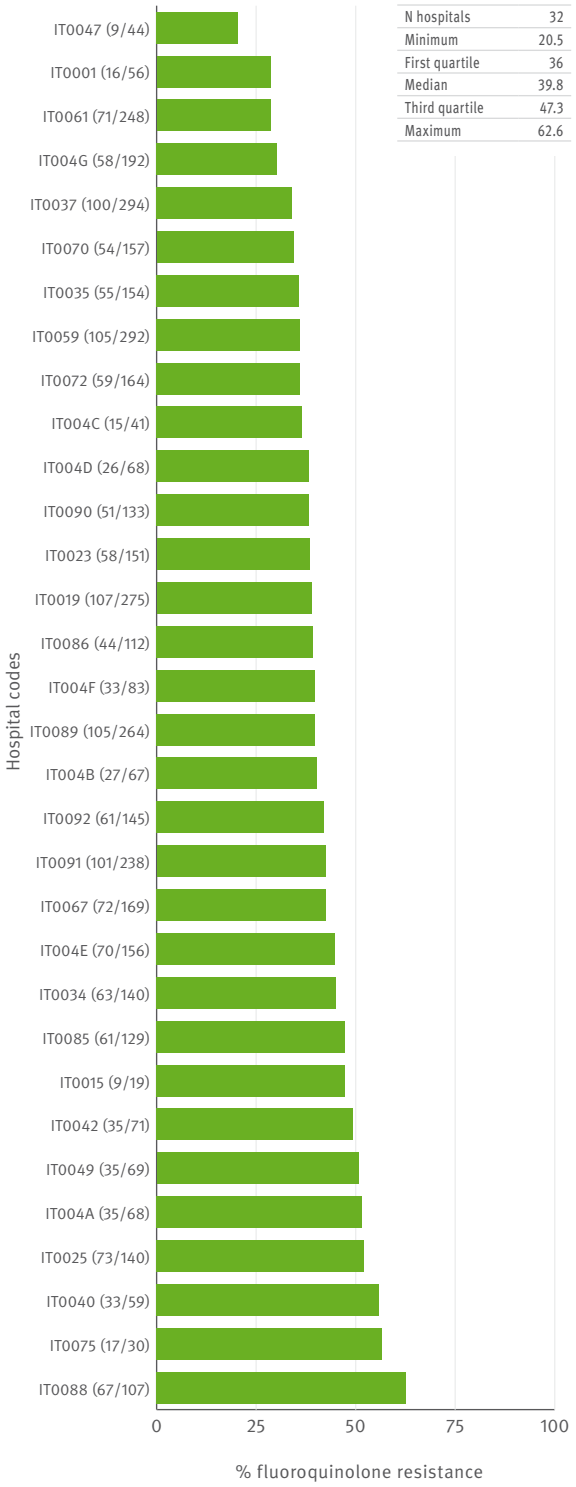
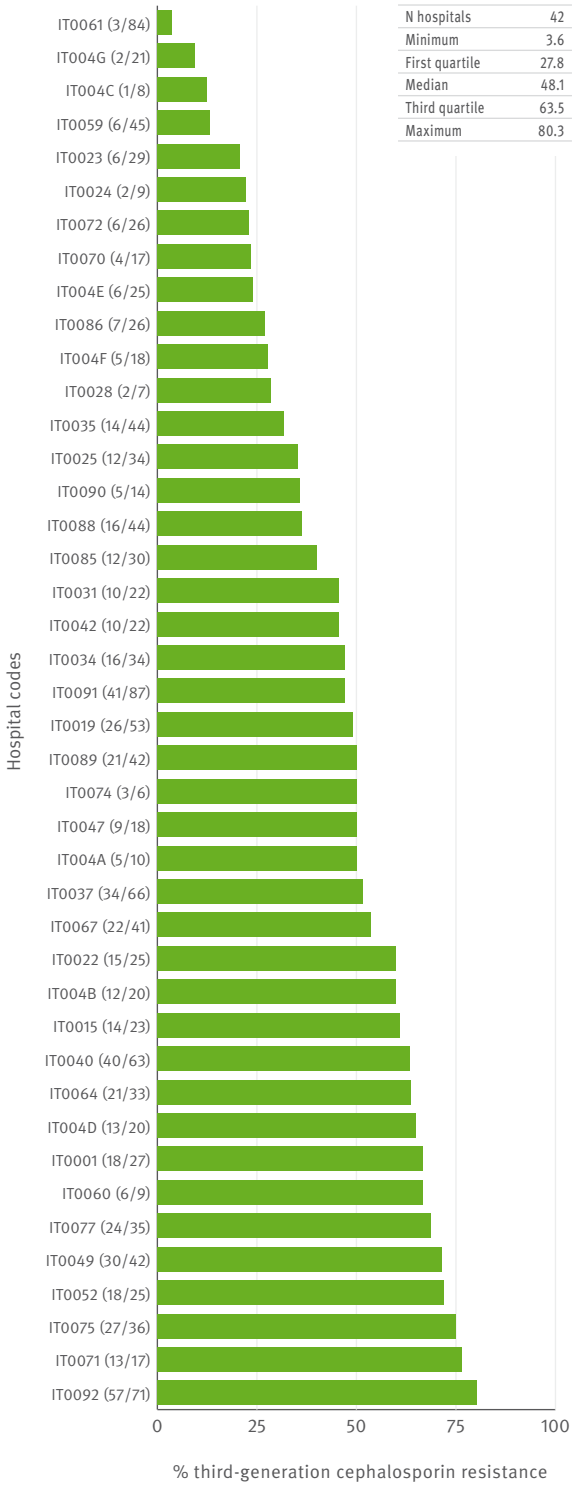


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Latvia

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2004–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2004	4	17	7	87	-	-	-	-	-	-	-	-
2005	5	36	7	127	-	-	-	-	-	-	-	-
2006	7	37	11	172	10	62	10	56	6	28	9	16
2007	6	31	12	169	9	76	8	57	7	27	6	16
2008	3	18	12	164	10	90	9	51	11	40	6	11
2009	7	30	12	188	9	86	8	48	10	44	7	18
2010	4	38	10	155	8	98	8	61	8	64	6	21
2011	5	51	11	197	9	132	8	59	9	65	4	12

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	-	<1	<1	<1	<1	6	<1	5	10
Penicillin RI	-	<1	<1	<1	<1	6	<1	5	13
Macrolides RI	-	7	3	3	<1	<1	3	5	<1
Staphylococcus aureus									
Oxacillin/Meticillin R	-	26	20	19	8	12	9	14	10
Escherichia coli									
Aminopenicilins R	-	-	-	44	43	48	43	50	55
Aminoglycosides R	-	-	-	5	14	10	13	11	11
Fluoroquinolones R	-	-	-	10	17	14	24	14	17
Third-gen. cephalosporins R	-	-	-	6	14	11	12	12	16
Carbapenems R	-	-	-	<1	<1	<1	2	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	-	-	-	9	30	5	12	5	18
HL Gentamicin R	-	-	-	50	-	27	38	47	26
Vancomycin R	-	-	-	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	-	-	-	94	77	90	82	100	96
HL Gentamicin R	-	-	-	73	<1	78	79	83	42
Vancomycin R	-	-	-	<1	<1	7	18	13	9
Klebsiella pneumoniae									
Aminoglycosides R	-	-	-	25	22	52	43	55	34
Fluoroquinolones R	-	-	-	26	27	45	34	52	38
Third-gen. cephalosporins R	-	-	-	36	44	58	55	55	38
Carbapenems R	-	-	-	<1	<1	3	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	17	31	30	17	19	9
Ceftazidime R	-	-	-	29	13	36	17	10	9
Carbapenems R	-	-	-	13	6	40	7	14	8
Aminoglycosides R	-	-	-	47	31	44	22	29	25
Fluoroquinolones R	-	-	-	33	13	45	12	19	25

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	73	5	100	12	100	16	100	0	100	11	98	46	97	13
CSF	27	19	-	-	0	0	-	-	-	-	2	100	3	0
Gender														
Male	55	2	53	13	32	21	51	0	51	9	53	43	39	15
Female	45	17	47	10	68	14	49	0	49	14	47	50	61	10
Age (years)														
0–4	13	40	8	4	8	6	8	0	2	0	16	33	9	0
5–19	1	100	4	7	2	0	1	0	-	-	2	100	-	-
20–64	58	2	47	14	41	15	43	0	49	14	49	52	42	29
65 and over	27	5	40	9	49	19	47	0	47	10	33	43	48	0
Unknown	-	-	1	100	0	0	-	-	2	0	1	0	-	-
Hospital department														
ICU	57	5	23	19	25	28	38	0	67	13	43	61	48	19
Internal med.	9	29	41	11	27	15	24	0	16	14	19	40	33	9
Surgery	-	-	8	15	4	44	8	0	9	0	4	40	6	0
Other	19	13	20	9	27	7	19	0	7	0	18	35	9	0
Unknown	14	9	8	0	17	8	11	0	2	0	16	30	3	0

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Latvia

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

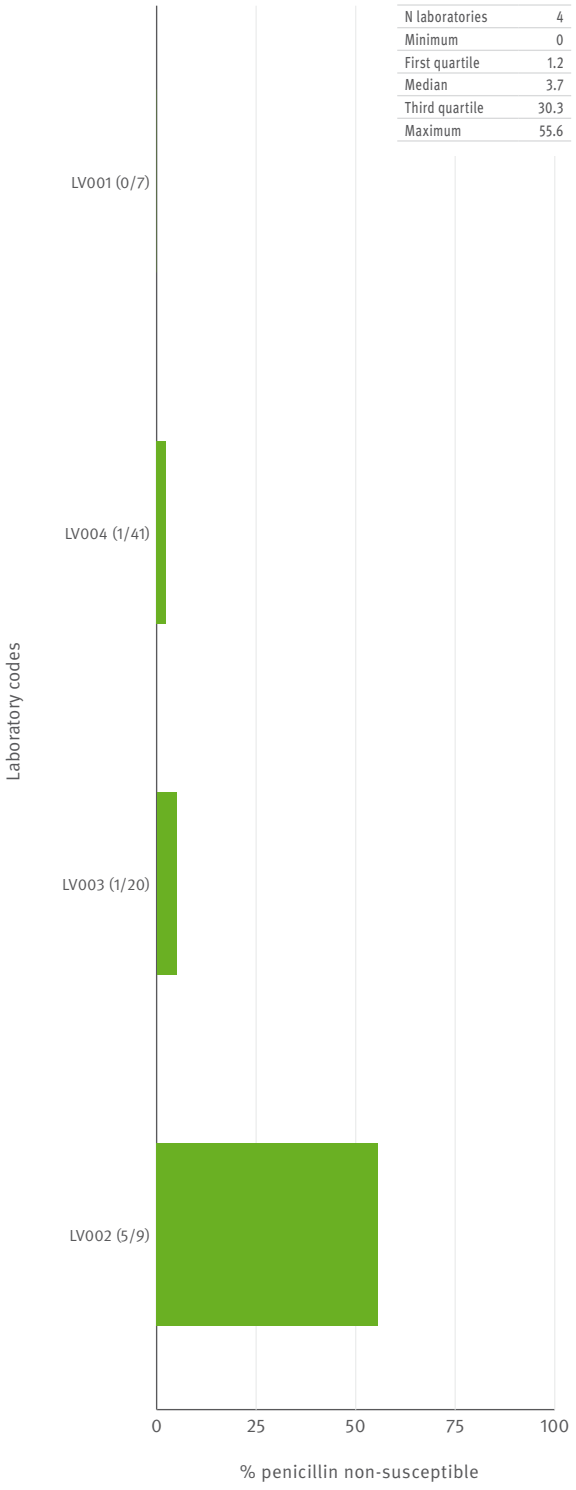


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

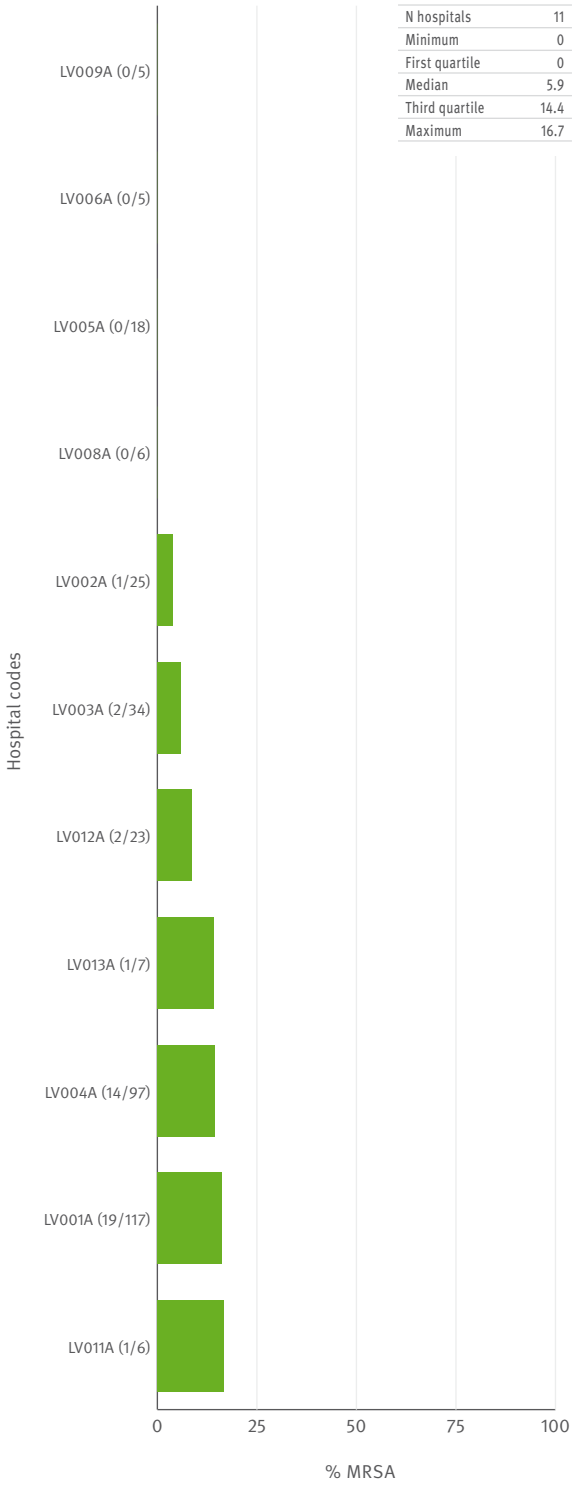


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

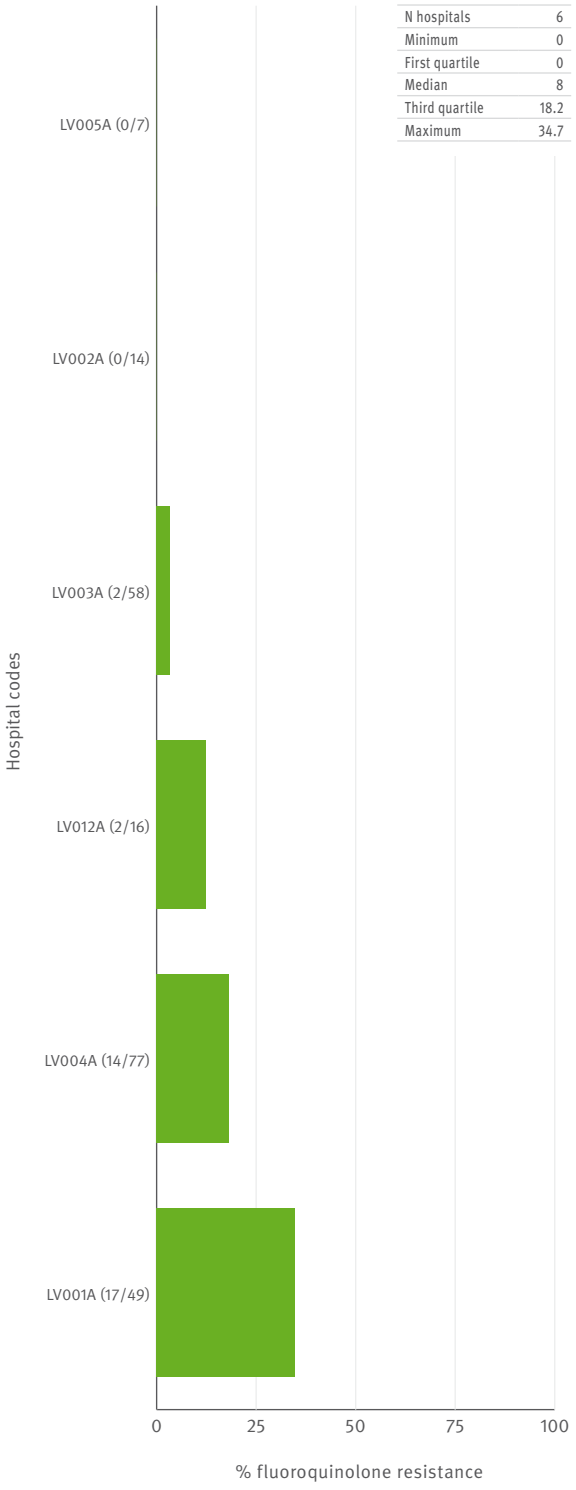


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)

Lithuania

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2006–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2006	9	35	13	167	11	171	8	30	8	35	7	14
2007	10	67	12	240	13	235	10	56	10	41	7	21
2008	11	48	12	278	12	304	10	67	11	54	7	21
2009	10	46	13	258	13	297	11	57	12	68	8	21
2010	9	40	11	257	10	333	10	59	9	81	8	31
2011	8	48	10	279	10	385	9	74	10	137	6	30

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	-	-	-	<1	1	<1	7	8	2
Penicillin RI	-	-	-	16	4	2	9	13	19
Macrolides RI	-	-	-	<1	9	6	7	<1	26
Staphylococcus aureus									
Oxacillin/Meticillin R	-	-	-	13	9	11	11	14	6
Escherichia coli									
Aminopenicilins R	-	-	-	55	50	54	58	56	48
Aminoglycosides R	-	-	-	15	12	12	15	15	10
Fluoroquinolones R	-	-	-	12	9	14	15	14	13
Third-gen. cephalosporins R	-	-	-	5	7	6	8	9	7
Carbapenems R	-	-	-	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	-	-	-	5	3	5	3	13	10
HL Gentamicin R	-	-	-	50	41	33	48	41	44
Vancomycin R	-	-	-	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	-	-	-	75	100	88	95	88	96
HL Gentamicin R	-	-	-	75	81	78	64	87	88
Vancomycin R	-	-	-	<1	<1	<1	11	8	8
Klebsiella pneumoniae									
Aminoglycosides R	-	-	-	26	37	41	56	52	55
Fluoroquinolones R	-	-	-	3	8	23	37	36	55
Third-gen. cephalosporins R	-	-	-	23	27	36	57	51	61
Carbapenems R	-	-	-	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	21	5	14	20	6	13
Ceftazidime R	-	-	-	31	<1	10	14	10	21
Carbapenems R	-	-	-	21	30	24	19	27	20
Aminoglycosides R	-	-	-	29	33	38	19	13	13
Fluoroquinolones R	-	-	-	46	38	35	33	16	17

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	92	18	100	10	100	13	100	0	100	8	99	56	100	23
CSF	8	0	-	-	-	-	-	-	-	-	1	100	-	-
Gender														
Male	70	11	54	9	37	16	65	0	54	15	60	60	67	20
Female	30	27	45	11	62	12	35	0	46	0	40	52	33	30
Unknown	-	-	1	0	0	0	-	-	-	-	-	-	-	-
Age (years)														
0–4	26	26	4	5	4	15	10	0	8	0	6	85	2	0
5–19	5	25	6	0	2	7	1	0	6	33	1	100	2	0
20–64	51	14	44	8	38	18	35	0	32	13	39	52	45	30
65 and over	18	6	45	13	56	10	54	0	54	4	54	56	52	19
Unknown	-	-	1	0	0	0	-	-	-	-	<1	100	-	-
Hospital department														
ICU	40	6	21	13	18	17	35	0	34	6	32	66	40	21
Internal med.	32	32	50	8	46	9	37	0	32	0	35	51	25	27
Surgery	-	-	10	15	6	9	4	0	6	33	9	45	3	0
Other	28	13	19	7	30	19	23	0	28	14	24	58	32	26
Unknown	-	-	-	-	-	-	1	0	-	-	-	-	-	-

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Lithuania

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

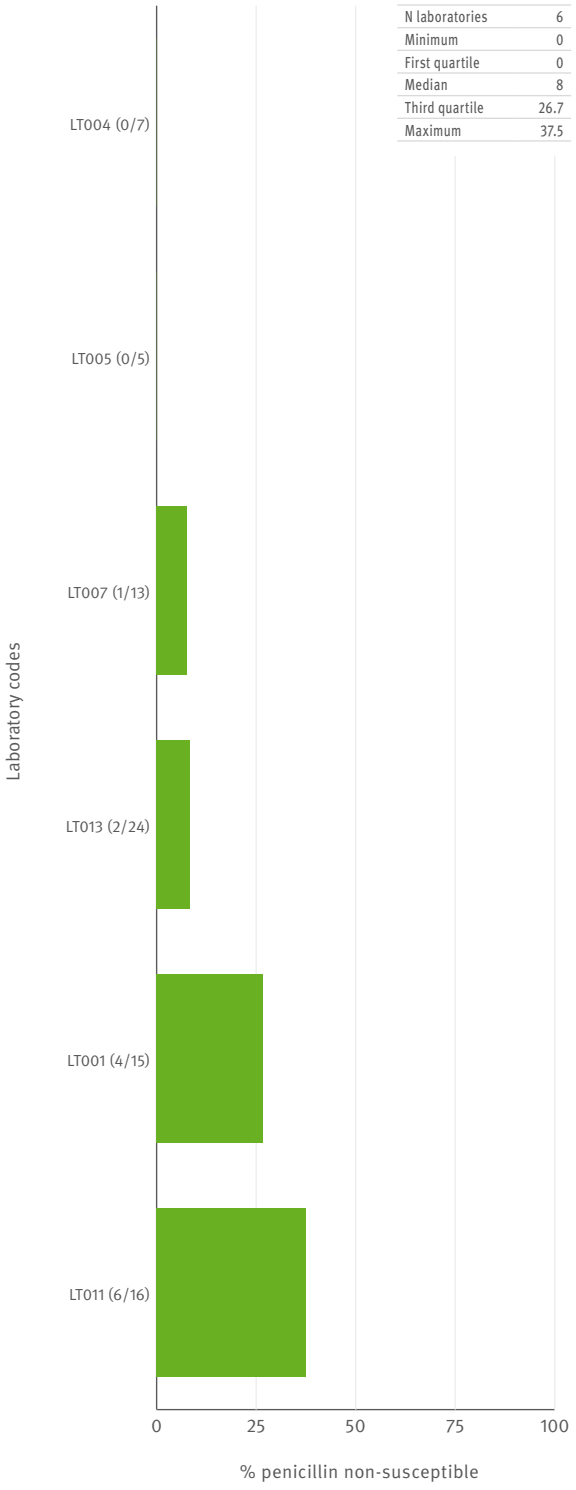


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

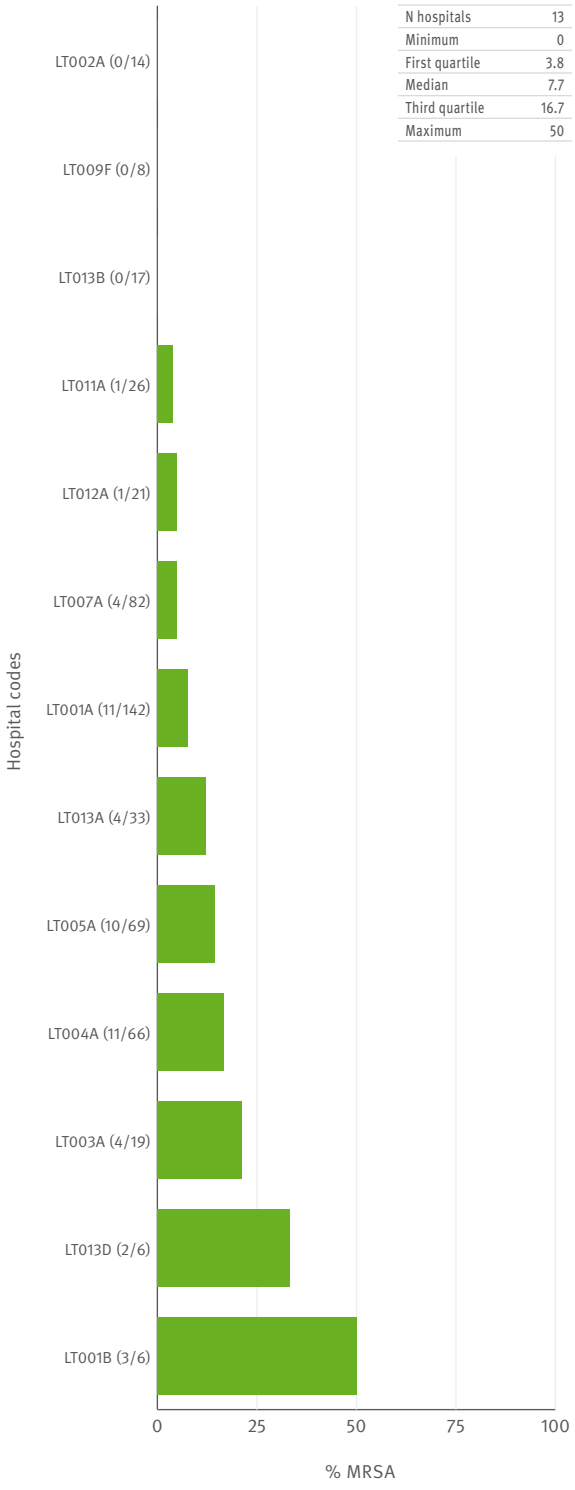


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

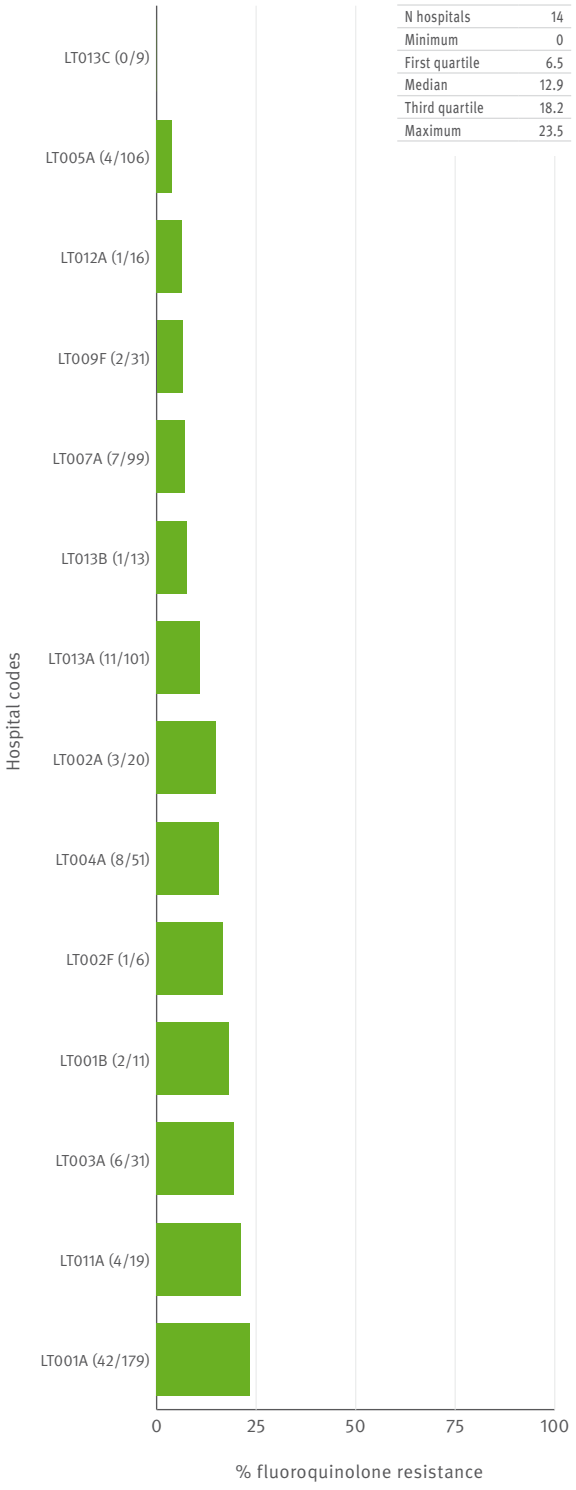


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)

Luxembourg

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	7	54	8	95	8	227	7	41	-	-	-	-
2004	6	36	7	96	7	216	5	28	-	-	-	-
2005	5	47	5	83	5	188	5	31	-	-	1	1
2006	5	31	5	77	5	167	4	42	4	21	4	23
2007	6	48	6	117	6	275	5	37	6	52	5	36
2008	6	59	5	117	6	303	5	61	6	52	4	33
2009	6	67	6	113	6	301	5	54	3	28	6	35
2010	6	50	6	134	6	354	6	70	6	59	6	32
2011	5	52	5	127	5	354	5	76	4	48	5	32

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	6	7	5	3	5	11	4	2
Penicillin RI	15	11	12	5	6	11	19	13	8
Macrolides RI	28	33	24	26	24	14	16	19	15
Staphylococcus aureus									
Oxacillin/Meticillin R	21	16	13	19	20	9	13	17	20
Escherichia coli									
Aminopenicilins R	49	49	49	46	49	56	57	57	52
Aminoglycosides R	4	4	7	6	5	8	9	19	8
Fluoroquinolones R	12	18	19	20	21	22	26	27	24
Third-gen. cephalosporins R	<1	<1	3	2	4	6	8	4	8
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	5	<1	<1	<1	<1	3	10	18	2
HL Gentamicin R	32	18	24	32	44	17	28	25	44
Vancomycin R	<1	<1	<1	<1	<1	3	10	<1	4
Enterococcus faecium									
Aminopenicilins RI	100	50	36	75	67	76	93	100	71
HL Gentamicin R	<1	<1	23	30	10	21	29	40	40
Vancomycin R	<1	<1	<1	<1	<1	5	36	11	4
Klebsiella pneumoniae									
Aminoglycosides R	-	-	-	<1	4	13	18	6	29
Fluoroquinolones R	-	-	-	6	12	12	21	9	33
Third-gen. cephalosporins R	-	-	-	10	2	19	25	6	35
Carbapenems R	-	-	-	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	<1	9	15	3	14	8	16
Ceftazidime R	-	-	<1	10	11	3	14	<1	9
Carbapenems R	-	-	<1	7	20	25	15	8	16
Aminoglycosides R	-	-	<1	4	22	6	9	8	16
Fluoroquinolones R	-	-	<1	10	36	15	11	20	19

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	87	10	100	18	100	25	100	4	100	17	98	18	97	13
CSF	13	8	-	-	-	-	-	-	-	-	2	50	3	0
Gender														
Male	54	9	63	15	42	25	72	4	65	23	58	21	55	17
Female	46	11	37	24	58	25	28	4	33	0	42	16	45	7
Unknown	-	-	-	-	-	-	-	-	2	100	-	-	-	-
Age (years)														
0–4	3	0	2	0	1	11	4	0	2	0	6	50	2	0
5–19	3	33	4	20	1	0	1	0	2	0	-	-	2	0
20–64	45	11	37	15	26	22	30	7	30	29	27	38	19	8
65 and over	49	8	57	21	72	27	65	3	65	13	67	8	78	14
Hospital department														
ICU	12	25	12	32	6	24	16	0	20	0	12	23	17	9
Internal med.	8	13	8	23	8	28	8	0	2	0	7	0	5	0
Surgery	4	0	6	25	11	26	8	0	9	25	15	25	5	33
Other	36	14	40	11	35	25	38	0	46	29	37	25	38	13
Unknown	40	3	33	20	40	24	30	13	24	9	28	10	36	13

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Luxembourg

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

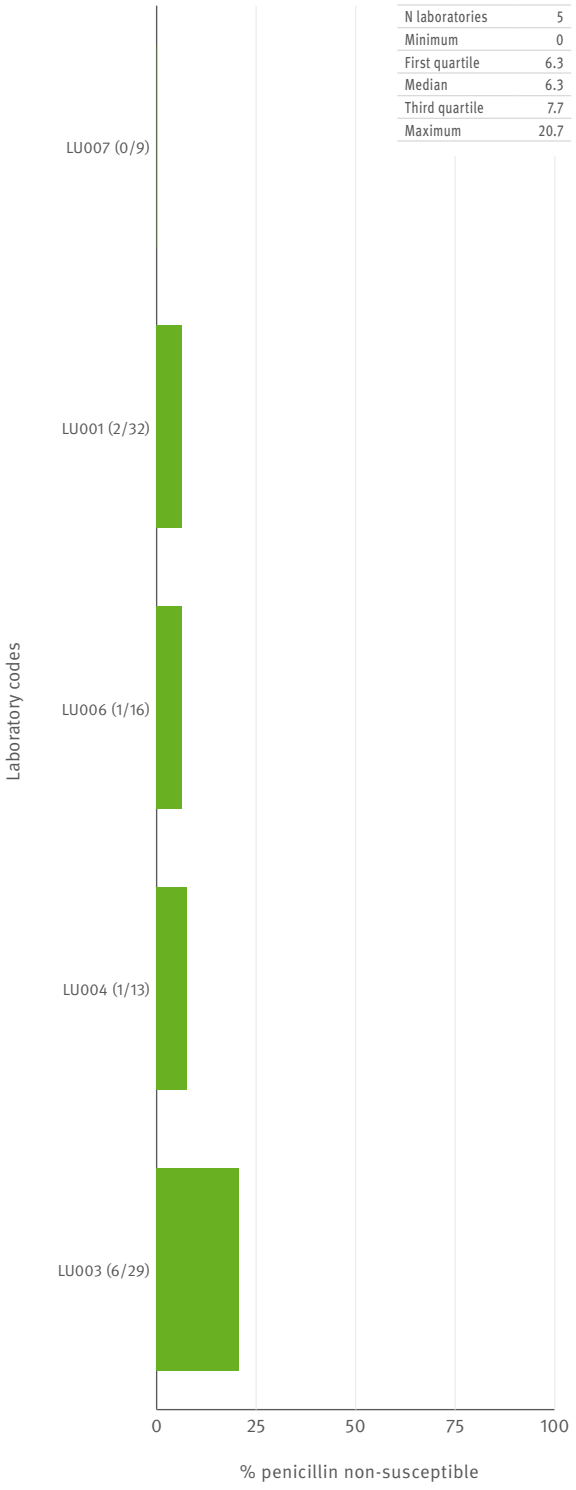


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

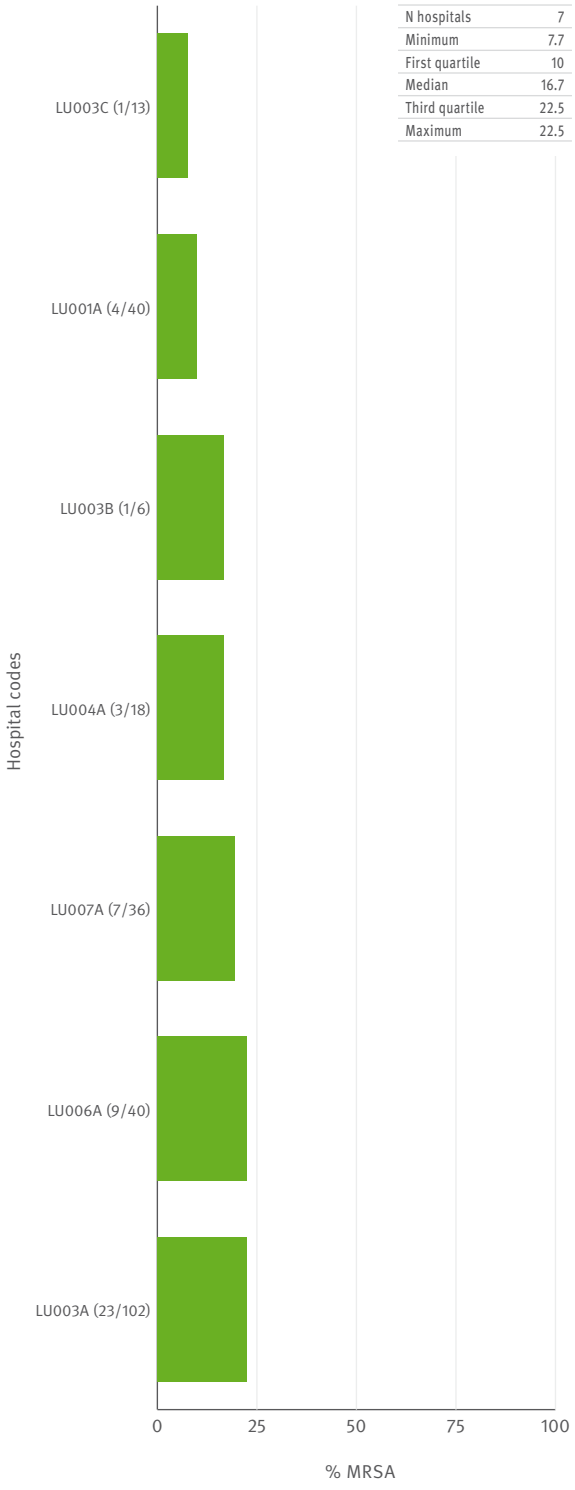
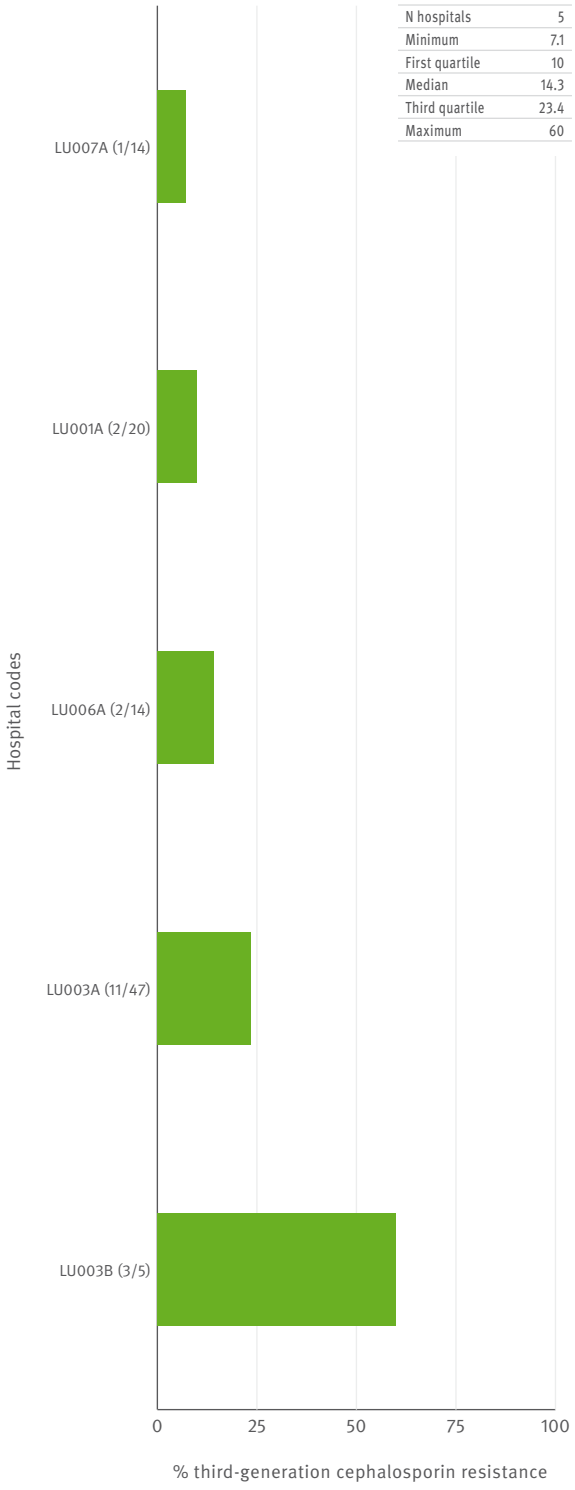


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Malta

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	1	9	1	121	1	91	1	26	-	-	-	-
2004	1	18	1	94	1	91	1	41	-	-	-	-
2005	1	13	1	77	1	85	1	38	1	18	1	45
2006	1	31	1	90	1	94	1	53	1	32	1	51
2007	1	13	1	105	1	117	1	37	1	28	1	36
2008	1	17	1	108	1	128	1	32	1	36	1	31
2009	1	8	1	85	1	158	1	36	1	38	1	58
2010	1	11	1	108	1	192	1	37	1	57	1	42
2011	1	11	1	130	1	220	1	53	1	52	1	42

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	8	3	<1	24	<1	11	10
Penicillin RI	<1	<1	15	7	<1	47	14	22	50
Macrolides RI	38	25	46	45	8	35	13	18	13
Staphylococcus aureus									
Oxacillin/Meticillin R	43	56	56	67	52	56	59	48	49
Escherichia coli									
Aminopenicilins R	39	48	51	56	54	52	54	44	53
Aminoglycosides R	18	20	7	15	20	22	21	22	16
Fluoroquinolones R	24	36	31	32	35	34	30	34	32
Third-gen. cephalosporins R	2	4	1	4	13	21	15	16	13
Carbapenems R	<1	<1	<1	<1	<1	<1	1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	5	<1	3	2	3	<1	5	<1	<1
HL Gentamicin R	29	44	32	-	-	-	-	-	-
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	33	43	25	14	40	60	75	100	64
HL Gentamicin R	50	<1	<1	-	-	-	-	-	.
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	17	6	<1	<1	<1	12	7
Fluoroquinolones R	-	-	11	6	11	8	3	16	13
Third-gen. cephalosporins R	-	-	6	6	7	<1	<1	12	13
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	4
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	22	47	11	45	36	36	24
Ceftazidime R	-	-	11	30	3	33	29	14	12
Carbapenems R	-	-	18	20	11	30	21	24	24
Aminoglycosides R	-	-	16	8	8	23	21	31	33
Fluoroquinolones R	-	-	44	24	11	19	22	24	13

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	95	39	100	49	100	33	100	0	100	0	100	13	96	24
CSF	5	0	-	-	0	0	-	-	-	-	-	-	4	0
Gender														
Male	36	0	53	50	40	39	59	0	73	0	39	16	58	24
Female	55	54	35	45	48	28	34	0	19	0	49	13	36	20
Unknown	9	50	12	52	11	34	6	0	8	0	12	0	6	20
Age (years)														
0–4	2	50	5	67	2	0	11	0	4	0	4	0	5	0
5–19	-	-	1	50	0	0	5	0	4	0	5	0	5	0
20–64	32	20	31	38	26	27	20	0	31	0	32	20	40	33
65 and over	59	42	63	53	72	36	64	0	62	0	59	9	51	19
Hospital department														
ICU	-	-	5	23	2	38	13	0	23	0	10	18	27	48
Internal med.	5	0	15	50	7	36	14	0	15	0	9	10	11	0
Surgery	-	-	6	87	2	22	6	0	8	0	3	0	4	33
Other	45	56	31	45	45	33	34	0	23	0	34	8	22	16
Unknown	50	22	42	49	44	33	33	0	31	0	44	15	36	16

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Malta

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

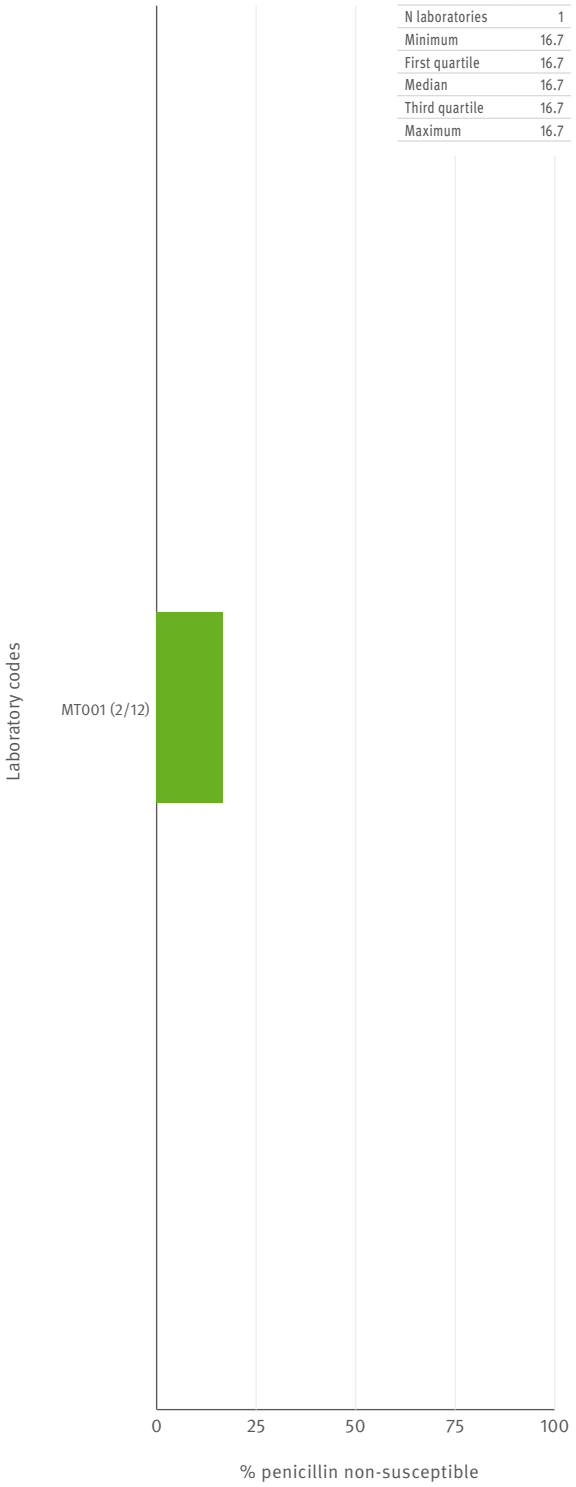


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

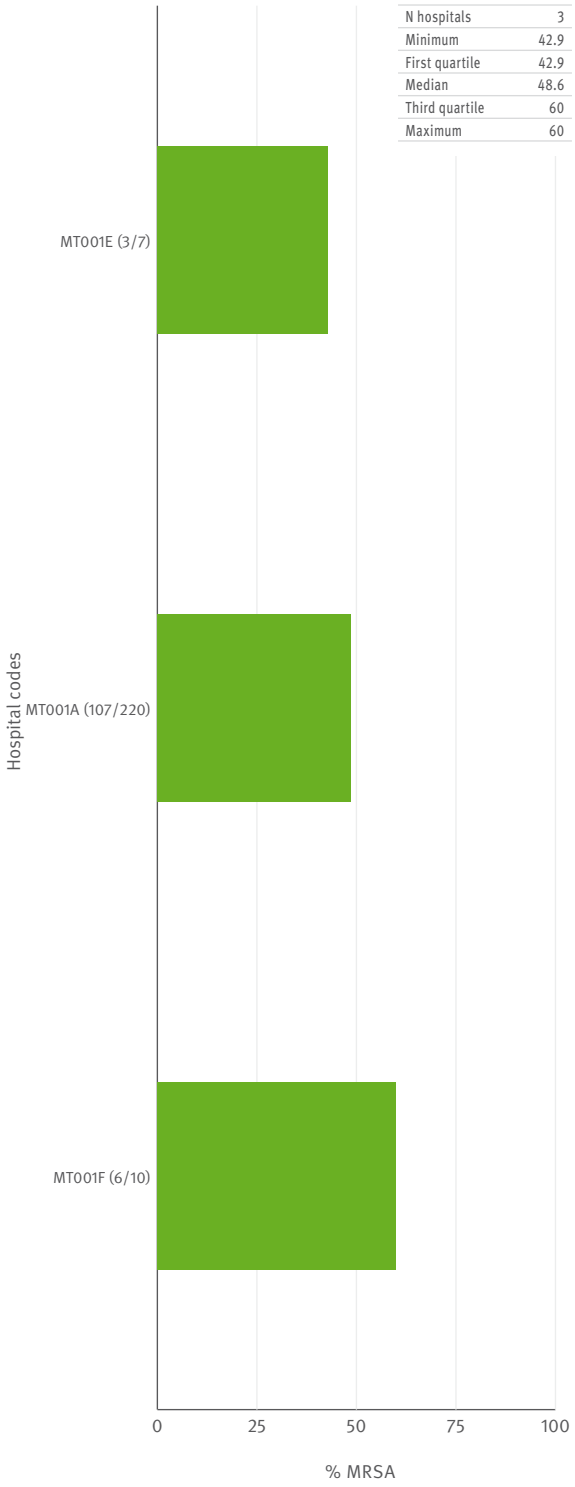


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

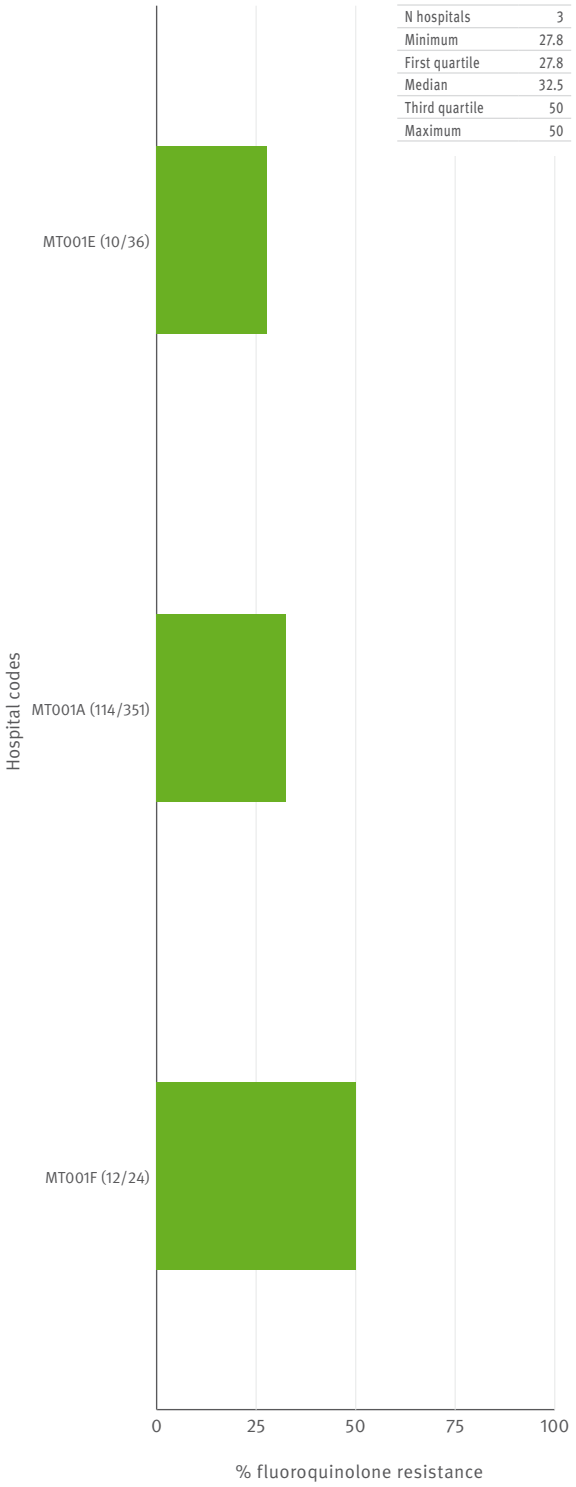
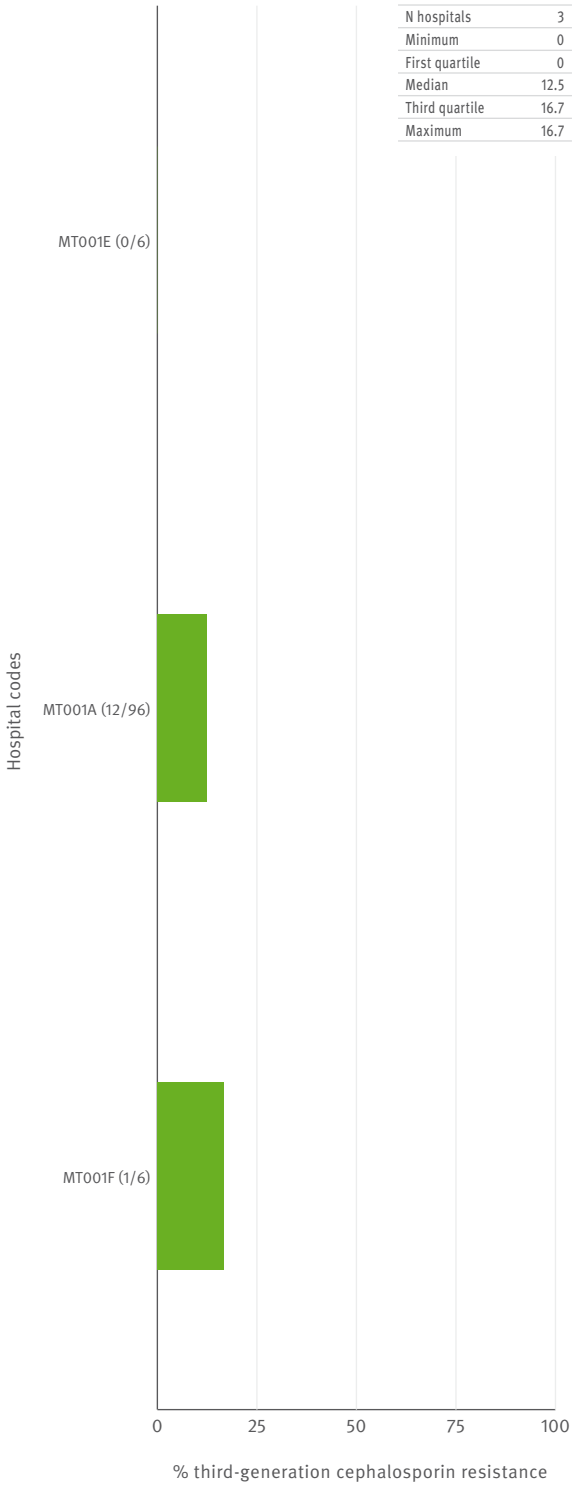


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Netherlands

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	24	891	23	1422	23	2133	23	480	-	-	-	-
2004	22	758	22	1339	21	2111	22	444	-	-	-	-
2005	23	815	23	1407	23	2201	23	563	16	301	16	210
2006	22	1006	23	1636	22	2905	23	776	18	458	19	330
2007	21	940	21	1471	21	2801	21	827	19	497	19	338
2008	17	723	16	1191	16	2283	17	632	15	463	15	345
2009	17	746	16	1035	16	2398	16	522	15	408	15	235
2010	22	971	21	1565	21	3422	20	834	20	647	21	376
2011	25	1289	23	1815	23	4436	23	1108	23	729	23	434

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Penicillin RI	1	2	1	1	2	2	1	2	1
Macrolides RI	5	8	11	8	7	7	5	6	5
Staphylococcus aureus									
Oxacillin/Meticillin R	1	1	<1	<1	2	<1	<1	1	1
Escherichia coli									
Aminopenicilins R	45	43	48	47	49	48	45	48	49
Aminoglycosides R	3	3	4	3	5	6	4	7	8
Fluoroquinolones R	7	7	10	11	13	14	11	14	14
Third-gen. cephalosporins R	1	1	2	3	4	5	4	5	6
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	3	3	5	5	<1	2	3	1
HL Gentamicin R	29	37	38	28	38	34	31	34	33
Vancomycin R	1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	30	42	61	73	83	86	89	89	91
HL Gentamicin R	20	20	40	50	62	53	76	65	66
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	5	4	5	7	3	7	8
Fluoroquinolones R	-	-	6	4	4	7	4	7	7
Third-gen. cephalosporins R	-	-	4	4	7	8	6	7	8
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	4	2	2	6	3	4	6
Ceftazidime R	-	-	5	5	4	6	4	3	5
Carbapenems R	-	-	5	2	2	6	3	3	3
Aminoglycosides R	-	-	7	4	3	4	1	2	5
Fluoroquinolones R	-	-	9	9	5	8	7	4	7

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	94	1	100	1	100	14	100	0	100	1	99	8	99	3
CSF	6	3	-	-	<1	9	-	-	-	-	1	14	1	17
Gender														
Male	50	2	59	1	50	18	70	0	62	1	57	10	67	4
Female	50	1	41	2	50	10	30	0	38	1	43	5	33	1
Age (years)														
0–4	4	5	4	1	2	8	3	0	2	0	1	0	2	8
5–19	2	0	3	2	1	7	1	0	2	0	1	15	1	0
20–64	40	2	33	2	26	15	28	0	36	1	29	9	30	5
65 and over	54	1	60	1	71	14	69	0	60	1	69	7	68	2
Hospital department														
ICU	10	2	9	5	8	14	16	0	40	1	11	19	17	6
Internal med.	9	2	13	0	17	13	14	0	12	2	17	5	15	3
Surgery	2	5	4	3	3	17	4	0	2	0	2	10	4	0
Other	40	1	29	1	29	14	28	0	20	2	25	8	25	2
Unknown	39	2	44	1	44	15	39	0	26	0	46	6	40	3

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Netherlands

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

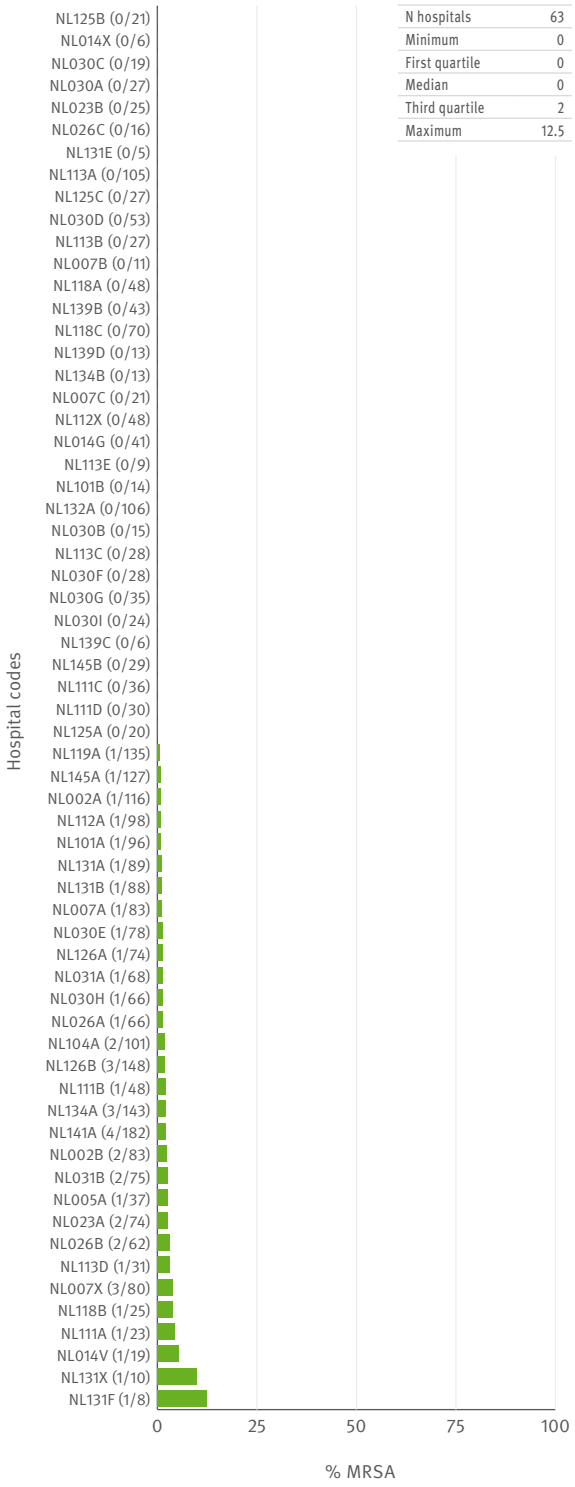


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

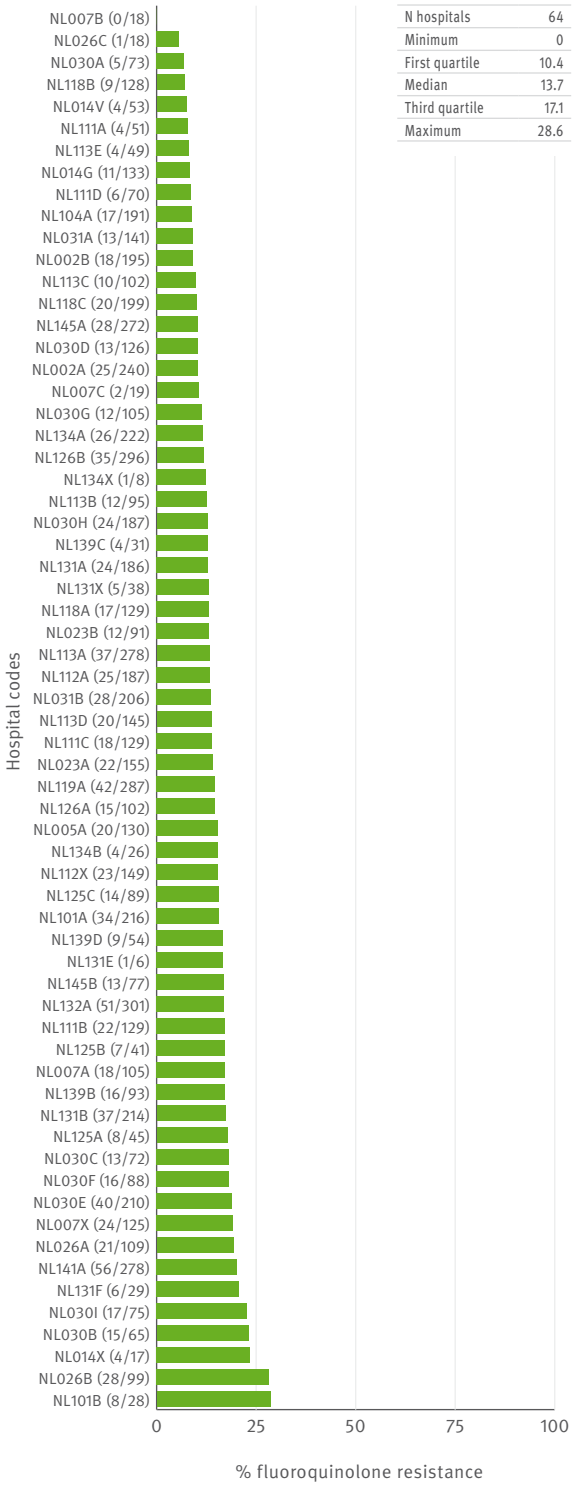
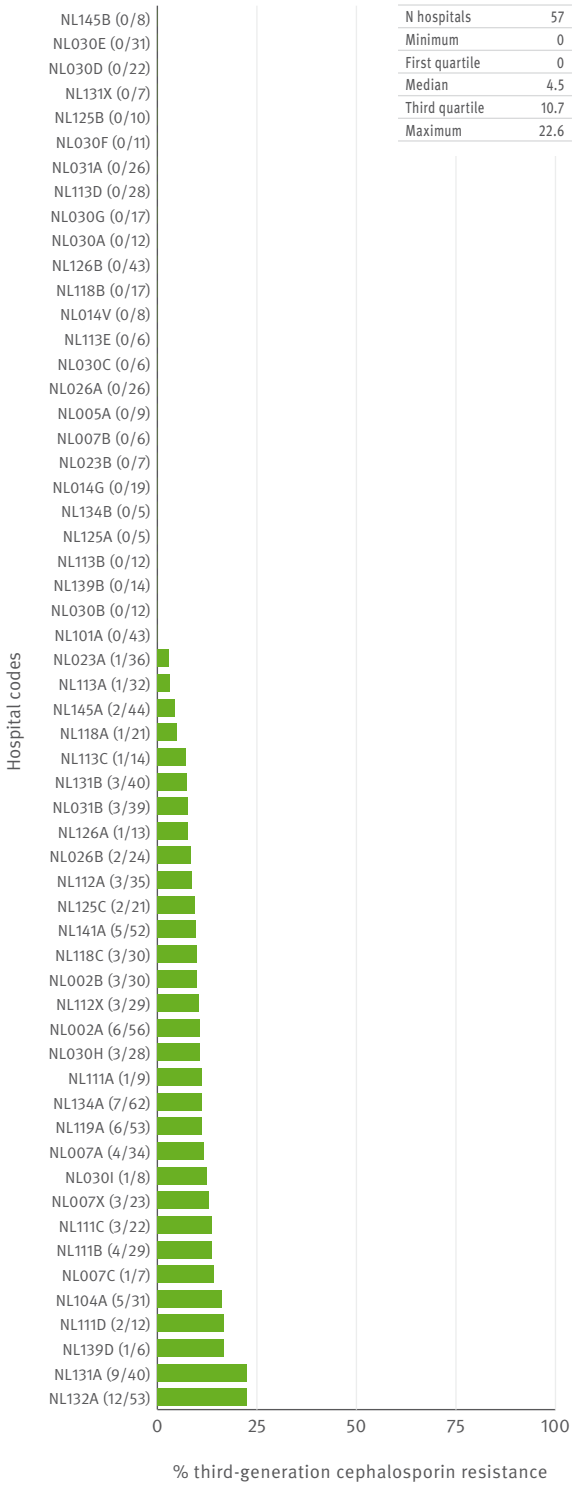


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Norway

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	11	512	11	506	11	1179	11	192	4	46	4	25
2004	11	600	11	516	11	1212	11	235	4	51	4	27
2005	11	606	11	553	11	1331	11	304	11	193	11	97
2006	12	601	12	734	12	1574	12	349	12	263	12	96
2007	13	616	13	794	13	1713	13	416	13	320	13	105
2008	13	576	13	837	13	1799	13	403	13	349	13	148
2009	12	554	12	909	12	1846	12	478	12	396	12	166
2010	15	576	15	1050	15	2277	15	563	15	479	15	168
2011	17	622	17	1223	17	2620	17	588	17	450	17	148

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Penicillin RI	<1	2	2	2	2	2	2	4	3
Macrolides RI	8	8	14	12	10	7	6	4	4
Staphylococcus aureus									
Oxacillin/Meticillin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Escherichia coli									
Aminopenicilins R	34	32	34	35	38	38	37	38	39
Aminoglycosides R	<1	<1	2	2	3	3	3	4	4
Fluoroquinolones R	2	4	5	5	7	7	9	9	9
Third-gen. cephalosporins R	<1	<1	<1	1	2	3	2	4	4
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	<1	3	3	2	2	<1	<1	<1
HL Gentamicin R	38	27	32	33	34	29	36	34	22
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	43	80	72	75	81	78	76	85	75
HL Gentamicin R	14	25	44	45	52	54	38	57	43
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	1	2
Klebsiella pneumoniae									
Aminoglycosides R	<1	2	3	<1	<1	1	3	2	3
Fluoroquinolones R	<1	<1	1	7	5	4	6	7	4
Third-gen. cephalosporins R	<1	<1	2	2	2	2	3	2	3
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	<1	13	3	3	2	6	4	3	5
Ceftazidime R	<1	<1	3	5	3	4	5	2	3
Carbapenems R	<1	4	3	9	9	7	5	1	4
Aminoglycosides R	<1	4	<1	1	2	<1	<1	<1	<1
Fluoroquinolones R	4	5	4	9	7	3	2	4	5

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	96	4	100	0	100	9	100	0	100	2	100	2	99	2
CSF	4	2	-	-	0	0	-	-	-	-	0	0	1	50
Gender														
Male	51	4	64	0	46	12	74	0	61	2	58	2	67	2
Female	49	3	36	0	54	6	26	0	39	0	42	3	33	3
Unknown	-	-	0	0	<1	50	0	0	<1	100	0	0	-	-
Age (years)														
0–4	5	7	3	0	1	3	4	0	1	25	1	0	1	0
5–19	2	4	4	1	1	3	1	0	1	0	1	0	1	0
20–64	40	3	34	1	26	11	24	0	34	2	30	4	28	2
65 and over	53	4	60	0	72	8	72	0	64	1	68	2	71	3
Hospital department														
ICU	7	3	8	1	4	12	8	0	13	0	6	4	7	4
Internal med.	35	4	32	1	32	8	30	0	30	0	26	4	29	3
Surgery	4	0	14	0	13	9	18	0	19	0	18	1	13	0
Other	51	3	45	0	49	9	42	0	37	5	48	2	48	3
Unknown	2	0	2	0	1	3	1	0	1	0	2	0	2	0

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Norway

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

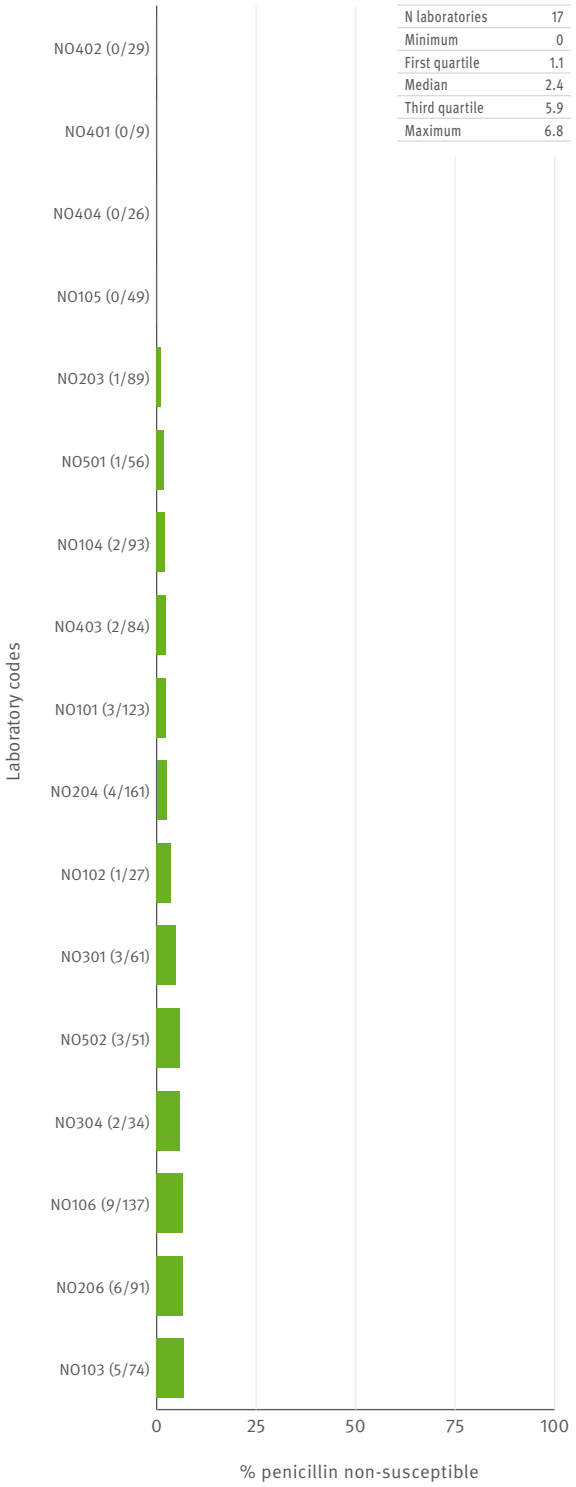


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

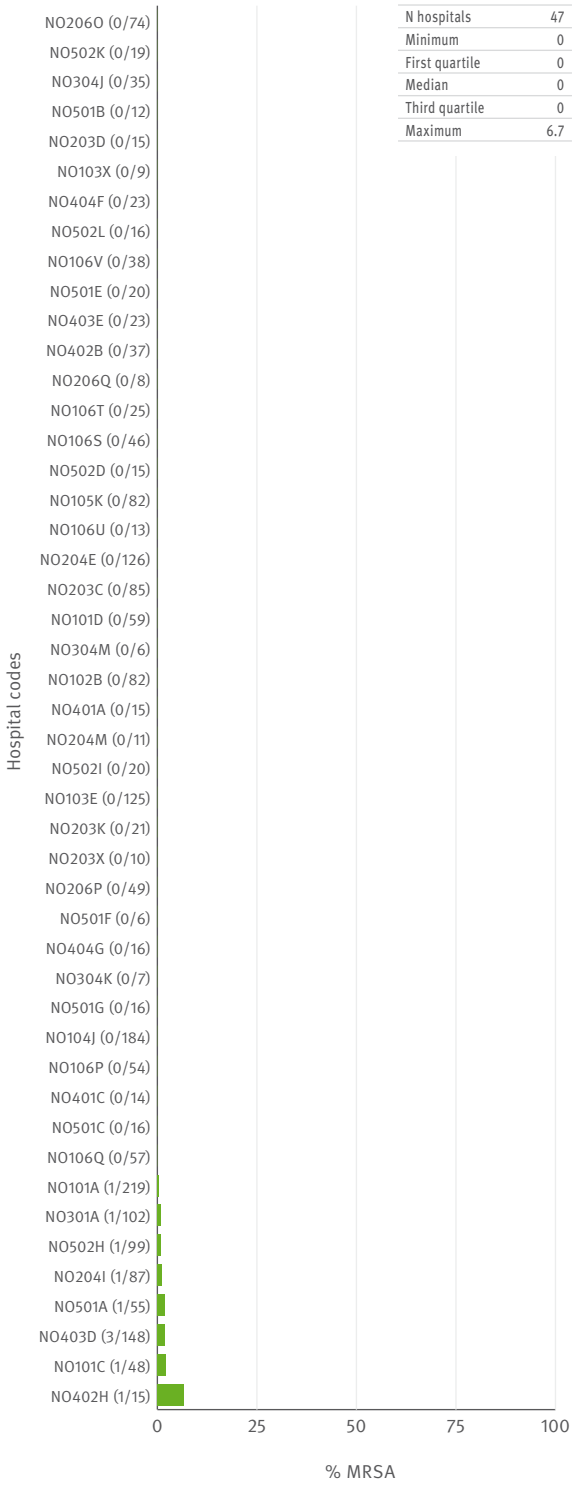


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

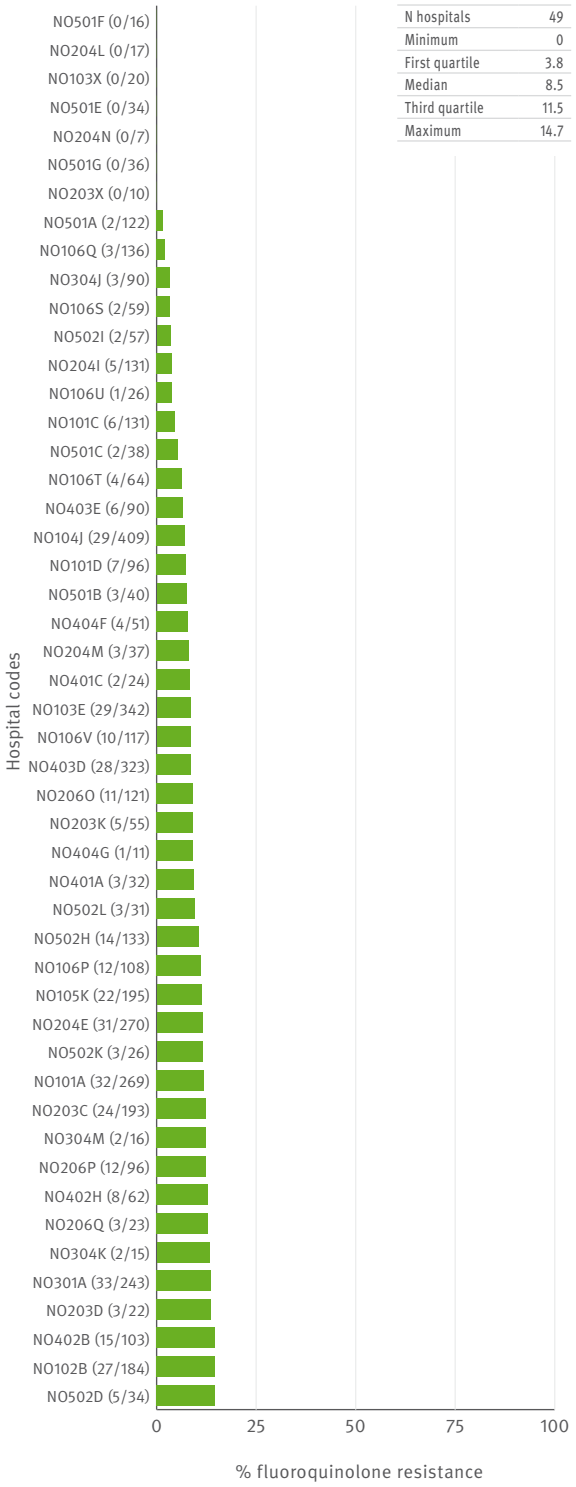
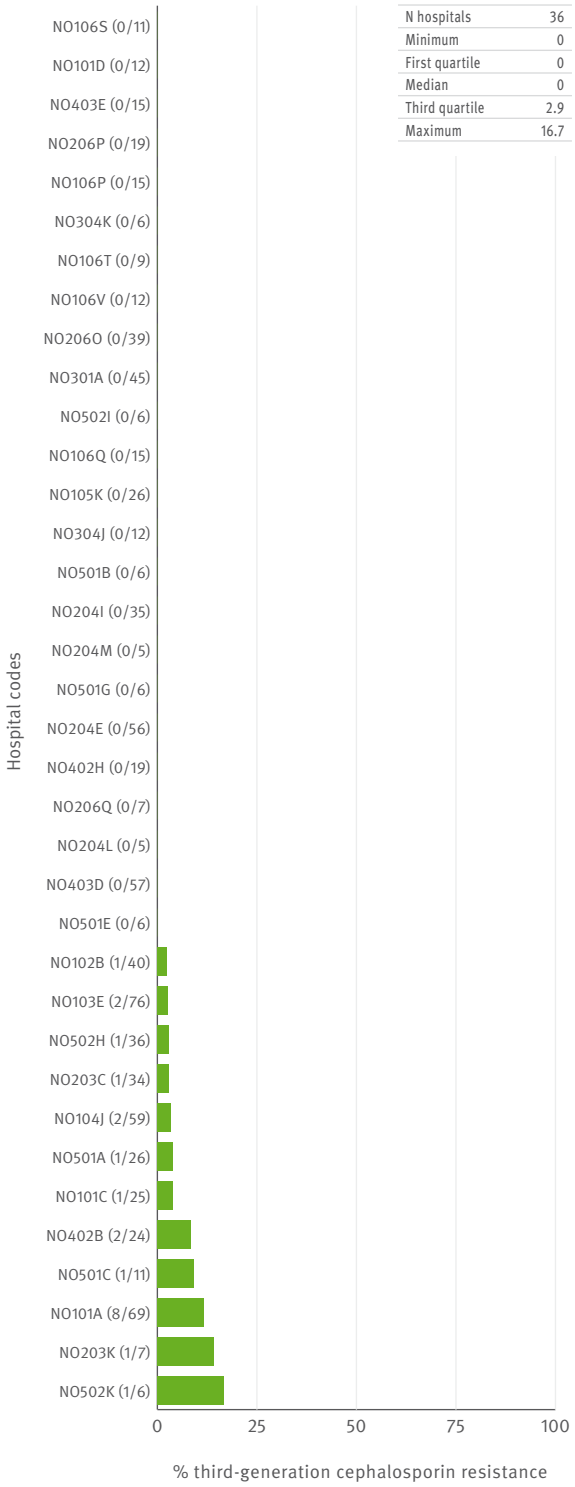


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Poland

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	11	16	24	166	25	124	16	64	-	-	-	-
2004	11	16	30	262	29	192	23	52	-	-	-	-
2005	6	6	30	198	30	176	21	54	17	53	14	26
2006	4	9	24	174	26	206	21	68	15	42	16	37
2007	10	22	24	185	27	256	20	71	18	32	23	67
2008	34	84	15	99	14	84	11	26	11	19	8	22
2009	21	71	30	551	29	625	28	267	25	151	27	153
2010	26	76	35	527	35	771	32	286	33	246	29	169
2011	41	166	45	868	45	1188	44	484	45	391	35	199

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	19	<1	17	<1	10	12	30	24	4
Penicillin RI	19	<1	33	<1	29	13	30	24	18
Macrolides RI	14	19	33	11	.	50	19	39	27
Staphylococcus aureus									
Oxacillin/Meticillin R	19	19	24	20	15	12	20	13	24
Escherichia coli									
Aminopenicilins R	50	45	56	55	56	54	65	60	62
Aminoglycosides R	10	5	7	11	6	7	7	9	8
Fluoroquinolones R	7	9	20	20	13	20	23	26	27
Third-gen. cephalosporins R	4	5	5	4	2	2	9	8	12
Carbapenems R	-	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	2	9	2	4	6	<1	3	1
HL Gentamicin R	48	33	48	50	46	29	39	36	48
Vancomycin R	<1	<1	<1	<1	2	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	91	86	95	95	88	78	98	95	93
HL Gentamicin R	55	100	62	85	84	67	75	65	70
Vancomycin R	<1	<1	5	<1	<1	<1	1	8	8
Klebsiella pneumoniae									
Aminoglycosides R	-	-	57	36	31	26	29	31	48
Fluoroquinolones R	-	-	34	29	3	32	32	33	58
Third-gen. cephalosporins R	-	-	66	38	34	37	49	40	60
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	50	43	36	32	30	29	31
Ceftazidime R	-	-	31	42	21	27	21	22	23
Carbapenems R	-	-	27	30	18	14	25	25	24
Aminoglycosides R	-	-	56	46	40	27	27	30	34
Fluoroquinolones R	-	-	31	41	37	13	26	28	30

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	83	21	100	20	100	27	100	0	100	8	99	50	98	24
CSF	17	18	-	-	<1	11	-	-	-	-	1	67	2	33
Gender														
Male	59	19	61	20	43	33	59	0	57	10	62	53	64	25
Female	41	21	38	20	56	22	40	1	42	6	38	48	36	24
Unknown	-	-	1	13	1	5	1	0	0	0	1	0	0	0
Age (years)														
0–4	7	44	5	13	4	5	8	0	7	0	7	36	3	17
5–19	6	33	2	28	1	17	1	0	2	60	2	25	4	50
20–64	48	18	47	19	38	27	42	1	47	11	50	54	51	30
65 and over	31	17	39	23	52	28	43	0	37	5	37	51	32	17
Unknown	8	11	6	15	5	28	6	0	8	0	4	47	10	12
Hospital department														
ICU	8	17	10	24	8	23	25	0	28	1	32	74	32	35
Internal med.	33	22	28	20	36	24	19	0	13	5	16	30	9	9
Surgery	1	0	9	34	6	50	15	0	13	0	13	54	9	32
Other	50	23	43	14	42	26	35	1	38	18	34	41	42	20
Unknown	8	0	10	26	8	34	7	0	8	8	5	23	7	15

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Poland

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

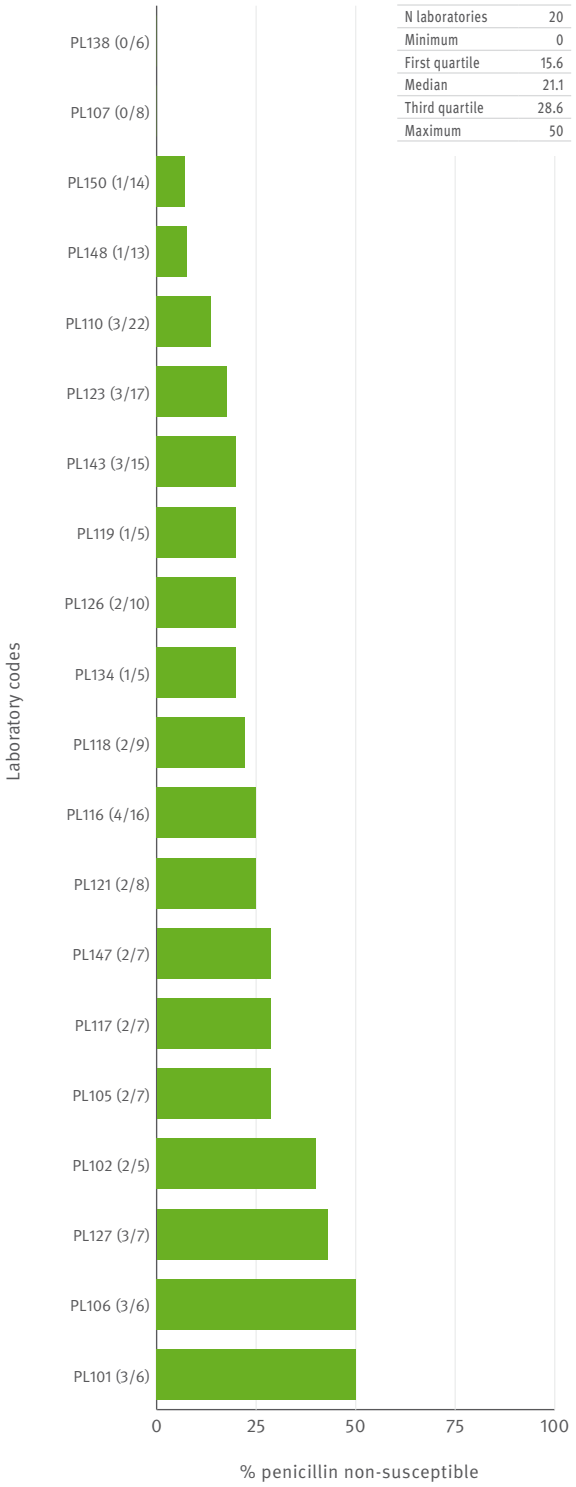


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

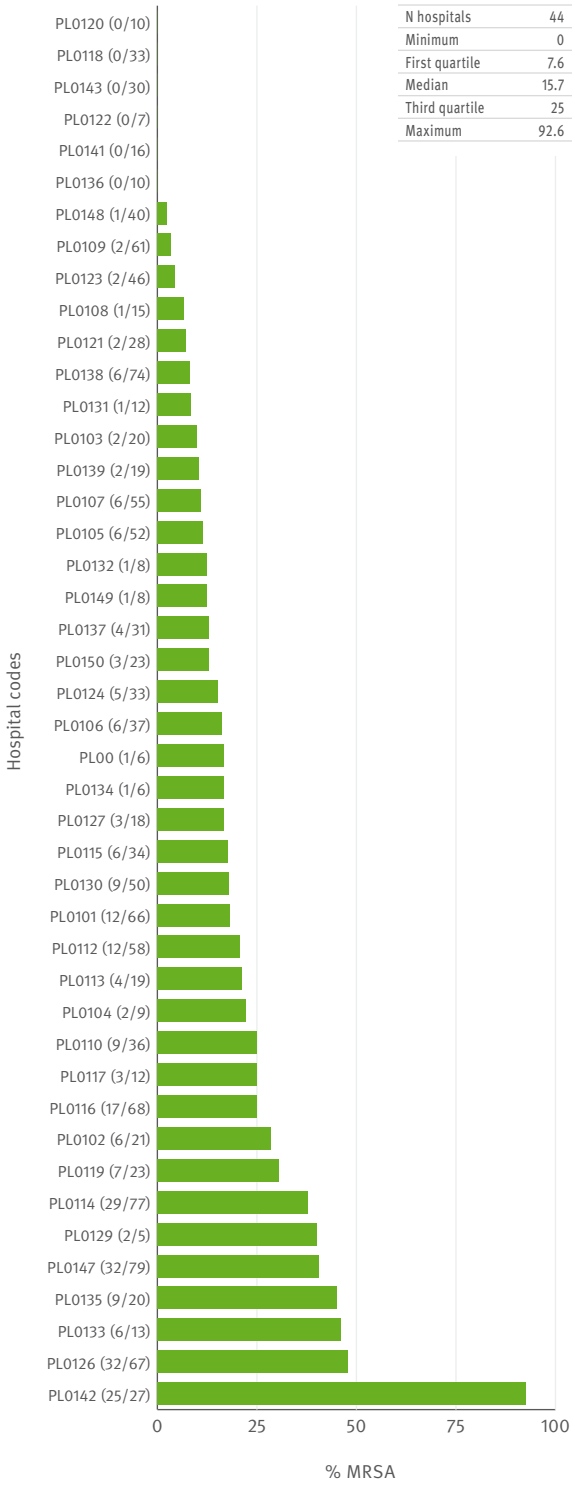


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

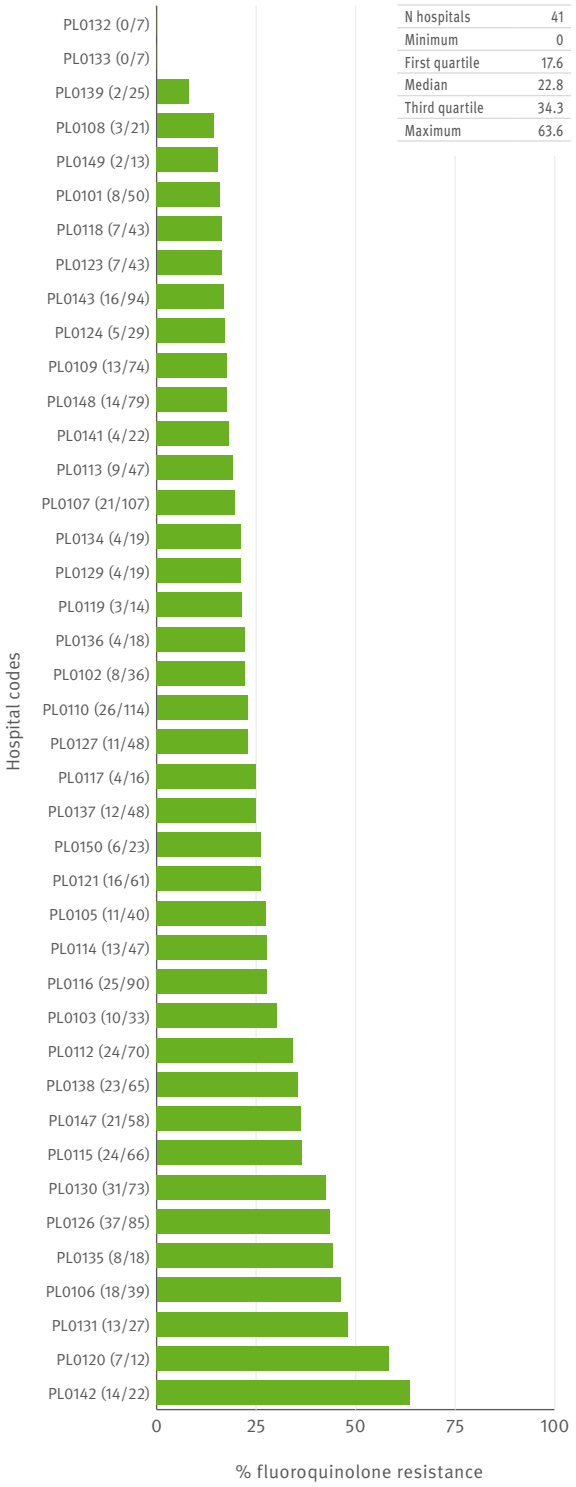
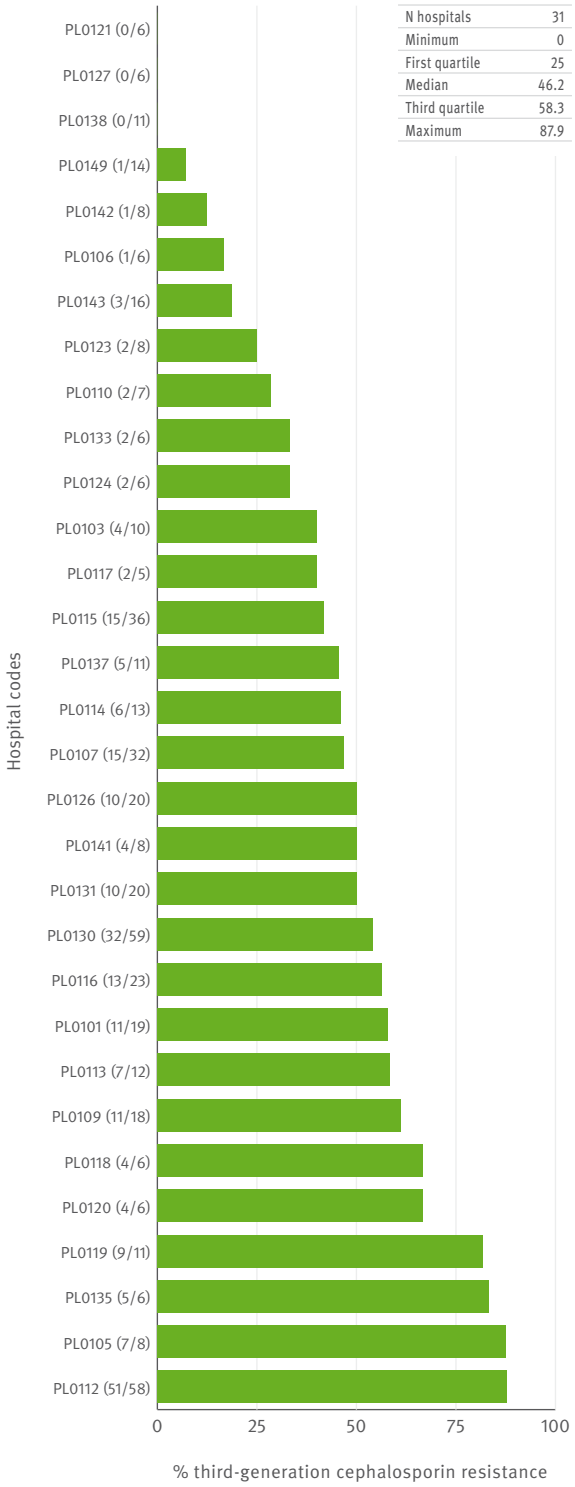


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Portugal

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	12	95	22	1033	21	792	18	398	-	-	-	-
2004	14	166	23	1063	19	761	19	410	-	-	-	-
2005	13	202	19	1153	19	1171	17	405	1	1	-	-
2006	15	183	17	1306	18	1331	17	464	13	315	11	266
2007	12	202	20	1383	20	1432	19	518	18	370	16	340
2008	14	260	20	1557	21	1625	20	588	21	543	19	467
2009	17	237	20	1824	20	2040	19	675	20	564	18	536
2010	12	156	18	1633	19	1980	19	621	19	596	19	548
2011	17	455	18	1507	18	1963	18	684	18	619	18	526

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	<1	<1	<1	18	15	8
Penicillin RI	20	27	17	17	16	18	18	15	10
Macrolides RI	-	20	19	21	23	22	22	22	15
Staphylococcus aureus									
Oxacillin/Meticillin R	45	46	47	48	48	53	49	53	55
Escherichia coli									
Aminopenicilins R	53	58	58	59	59	58	58	56	57
Aminoglycosides R	9	13	12	12	12	14	11	12	16
Fluoroquinolones R	26	27	29	28	30	29	28	27	27
Third-gen. cephalosporins R	7	8	12	10	10	10	9	10	11
Carbapenems R	-	-	-	-	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	4	5	<1	2	4	4	7	17	24
HL Gentamicin R	34	29	38	41	41	43	34	39	30
Vancomycin R	3	6	5	5	4	4	4	2	4
Enterococcus faecium									
Aminopenicilins RI	88	83	92	76	93	86	91	91	81
HL Gentamicin R	55	66	68	53	49	28	49	53	38
Vancomycin R	47	42	34	26	29	24	23	23	20
Klebsiella pneumoniae									
Aminoglycosides R	-	-	<1	13	11	19	20	27	32
Fluoroquinolones R	-	-	<1	20	18	22	28	31	36
Third-gen. cephalosporins R	-	-	-	21	17	26	28	28	35
Carbapenems R	-	-	-	-	<1	<1	<1	1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	15	14	17	17	18	19
Ceftazidime R	-	-	-	19	16	16	13	12	15
Carbapenems R	-	-	-	21	15	18	16	16	20
Aminoglycosides R	-	-	-	17	16	11	12	14	15
Fluoroquinolones R	-	-	-	21	19	23	21	20	26

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	96	11	100	54	100	27	100	3	100	22	99	32	99	18
CSF	4	24	-	-	<1	8	-	-	-	-	1	63	1	0
Gender														
Male	57	11	62	53	44	32	58	4	60	21	57	34	61	19
Female	43	12	38	55	56	24	42	2	40	22	43	30	39	17
Unknown	0	0	0	0	<1	18	0	0	1	100	-	-	<1	100
Age (years)														
0–4	9	19	5	15	2	11	3	0	1	0	3	30	1	8
5–19	4	12	2	17	1	14	0	0	1	67	1	50	1	0
20–64	41	12	30	44	30	24	26	3	40	25	35	31	38	19
65 and over	45	10	61	63	66	29	68	3	58	19	56	34	59	18
Unknown	0	0	2	54	2	22	2	0	-	-	5	18	1	15
Hospital department														
ICU	3	12	9	59	5	28	13	2	19	24	12	36	16	24
Internal med.	16	5	24	63	18	30	20	4	13	20	15	30	18	14
Surgery	0	0	10	62	5	31	12	3	16	28	8	28	9	17
Other	81	13	56	48	70	26	54	2	52	19	66	32	57	18
Unknown	-	-	1	41	1	27	1	8	-	-	1	33	<1	33

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Portugal

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

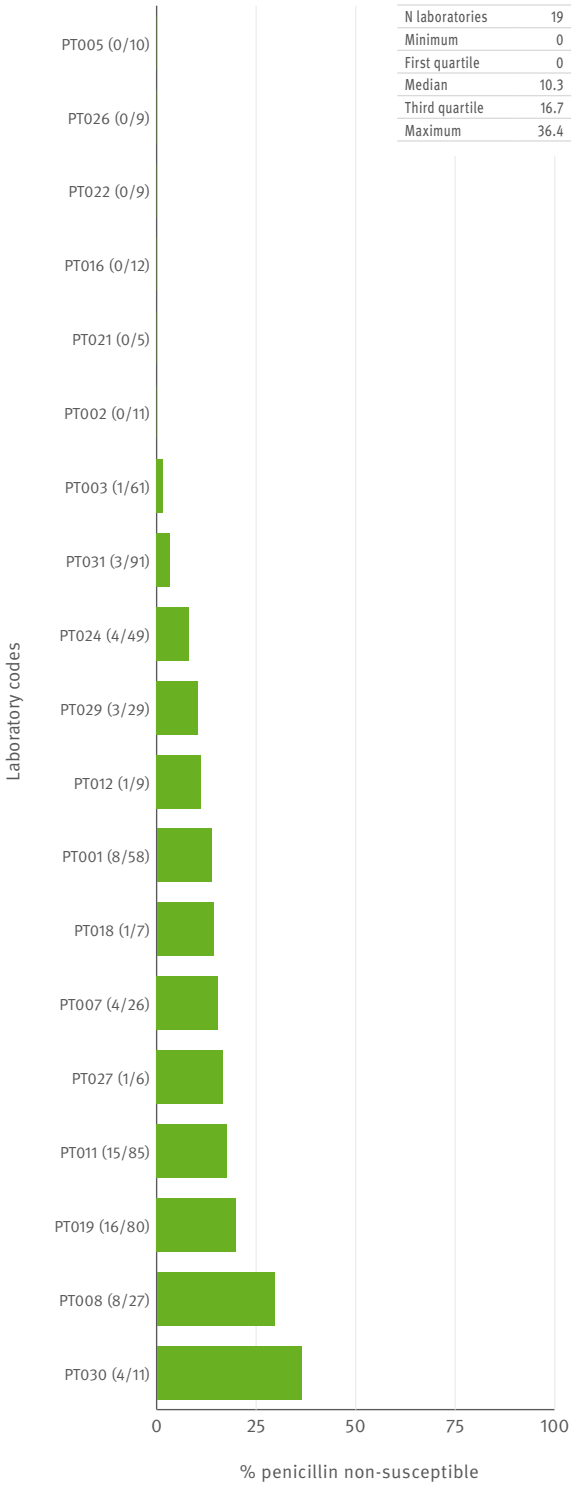


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

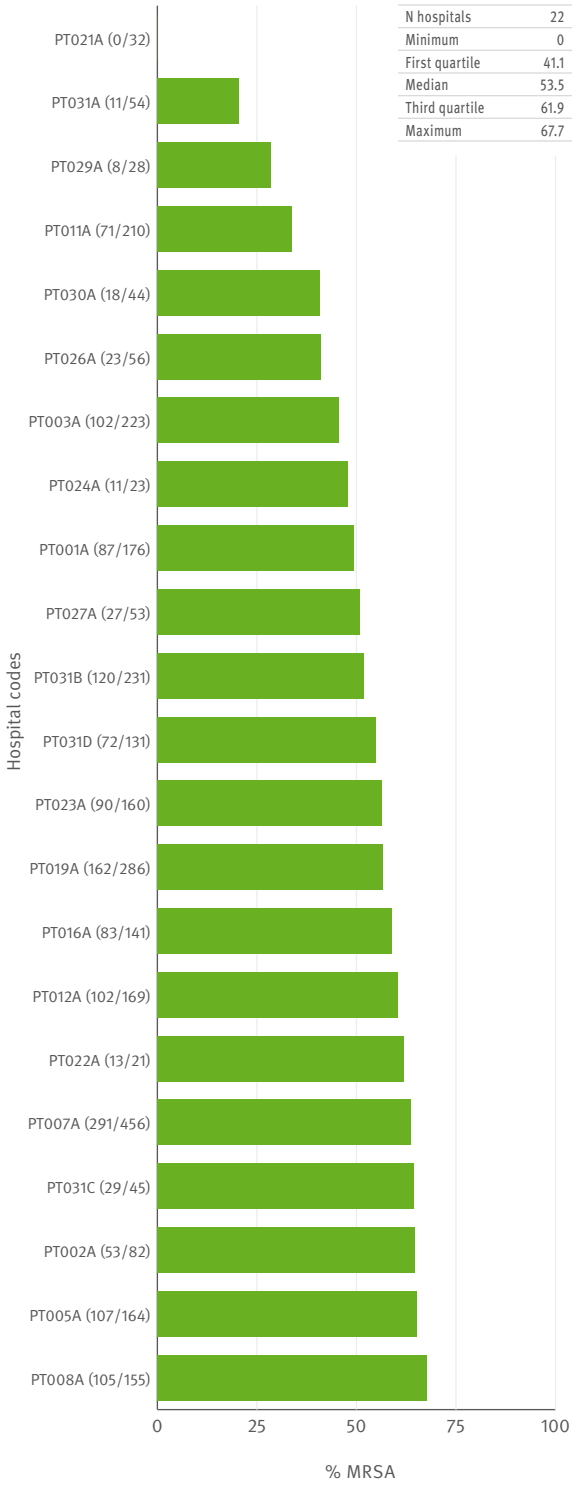


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

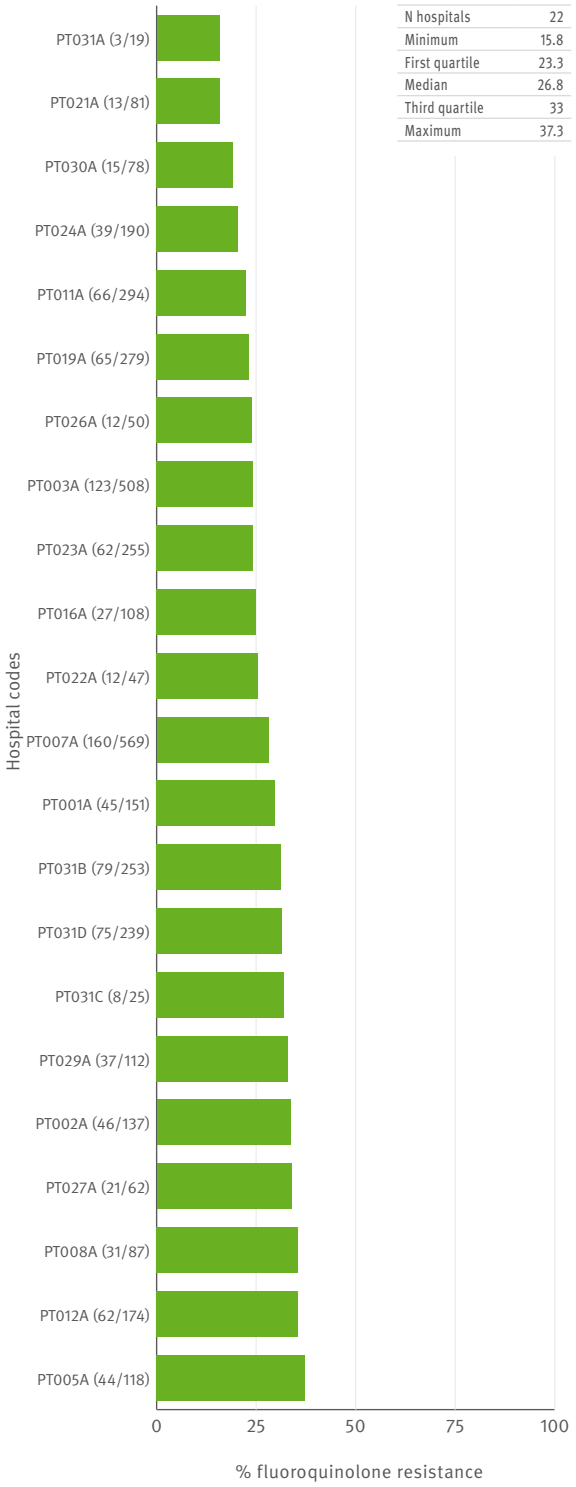
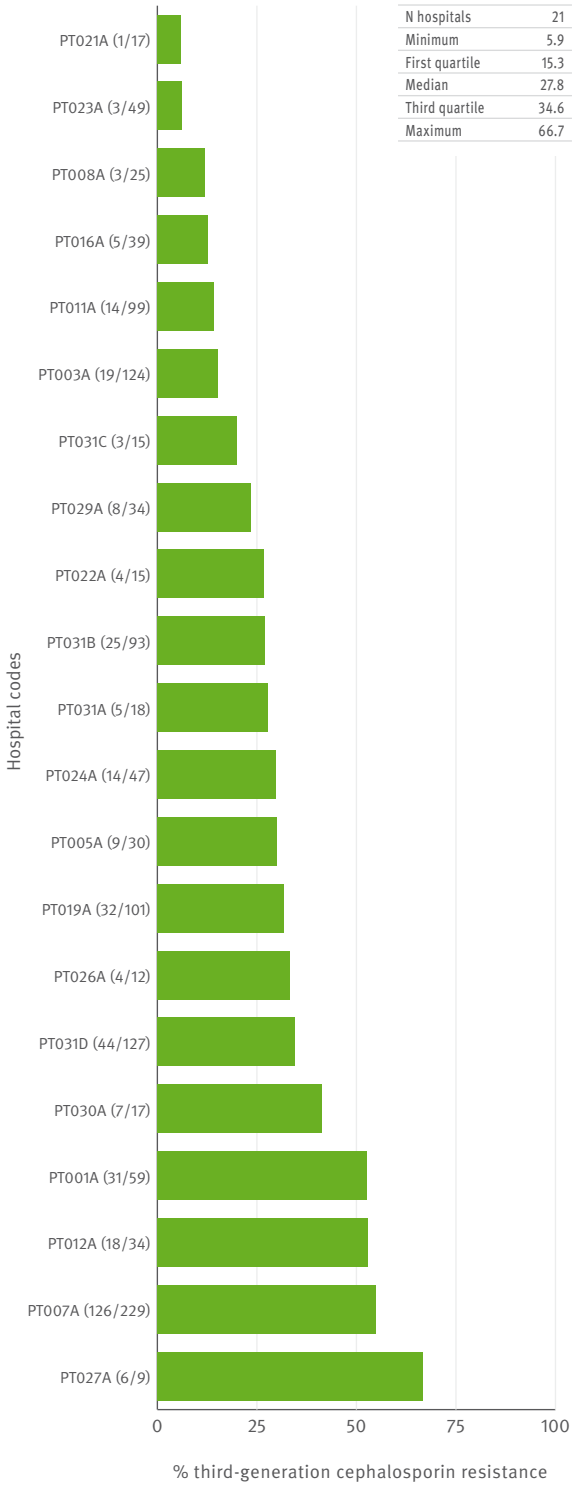


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Romania

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	5	26	9	85	9	50	5	12	-	-	-	-
2004	4	9	15	95	12	48	4	9	-	-	-	-
2005	5	18	13	93	13	84	7	14	1	3	2	23
2006	8	29	11	83	9	41	9	28	5	32	2	3
2007	5	27	9	42	9	63	5	14	6	30	2	4
2008	4	14	5	39	4	58	4	16	3	6	3	8
2009	3	17	6	48	7	90	5	27	4	27	4	24
2010	2	13	5	47	5	35	2	19	3	17	5	10
2011	3	36	4	107	3	91	3	31	4	25	3	9

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	21	11	22	10	22	54	24	31	61
Penicillin RI	33	11	39	28	33	69	29	31	61
Macrolides RI	29	<1	31	25	19	27	33	36	44
Staphylococcus aureus									
Oxacillin/Meticillin R	46	71	60	54	26	33	34	39	50
Escherichia coli									
Aminopenicilins R	70	79	78	85	76	55	60	83	68
Aminoglycosides R	21	33	14	41	35	24	11	12	20
Fluoroquinolones R	14	21	9	41	27	27	18	24	30
Third-gen. cephalosporins R	19	23	17	41	27	24	14	21	22
Carbapenems R	<1	3	<1	3	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	29	<1	<1	25	10	13	<1	11
HL Gentamicin R	25	<1	50	15	50	22	42	-	-
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	86	100	100	100	100	100	100	80	90
HL Gentamicin R	63	100	70	80	67	50	71	-	-
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	100	91	80	60	32	71	50
Fluoroquinolones R	-	-	33	34	23	20	11	29	30
Third-gen. cephalosporins R	-	-	100	94	80	50	65	71	44
Carbapenems R	-	-	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	61	33	25	25	31	63	67
Ceftazidime R	-	-	52	<1	<1	13	30	60	63
Carbapenems R	-	-	61	<1	<1	13	46	58	67
Aminoglycosides R	-	-	64	33	25	38	38	50	67
Fluoroquinolones R	-	-	64	33	25	25	31	56	75

Demographic characteristics

Table 3: Selected details on invasive isolates from the reporting period 2009 and 2010

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	57	46	100	47	99	27	100	0	100	0	100	55	100	68
CSF	43	62	-	-	1	100	-	-	-	-	-	-	-	-
Gender														
Male	57	50	69	45	54	42	75	0	73	0	60	56	74	79
Female	41	55	29	53	46	11	25	0	27	0	38	56	26	40
Unknown	2	100	2	33	-	-	-	-	-	-	2	0	-	-
Age (years)														
0–4	12	50	5	63	1	0	11	0	64	0	26	91	32	50
5–19	12	50	5	13	4	33	-	-	5	0	7	67	11	100
20–64	10	0	54	45	51	25	36	0	14	0	10	25	21	50
65 and over	22	64	10	44	35	29	18	0	-	-	10	50	21	75
Unknown	43	62	25	56	9	43	36	0	18	0	48	40	16	100
Hospital department														
ICU	-	-	1	100	-	-	-	-	-	-	-	-	16	100
Internal med.	-	-	5	57	6	0	-	-	-	-	5	0	11	0
Surgery	-	-	1	0	-	-	-	-	5	0	5	100	11	100
Other	57	46	58	42	53	33	64	0	77	0	40	71	47	56
Unknown	43	62	35	56	41	25	36	0	18	0	50	43	16	100

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Romania

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

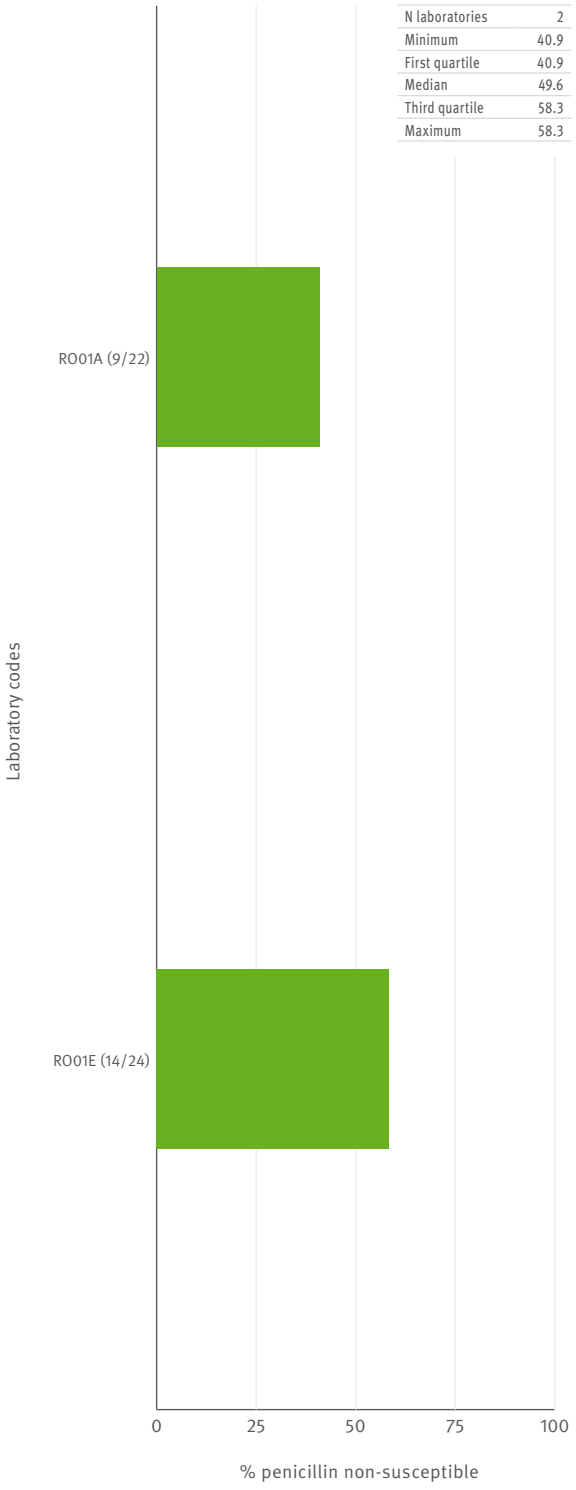


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

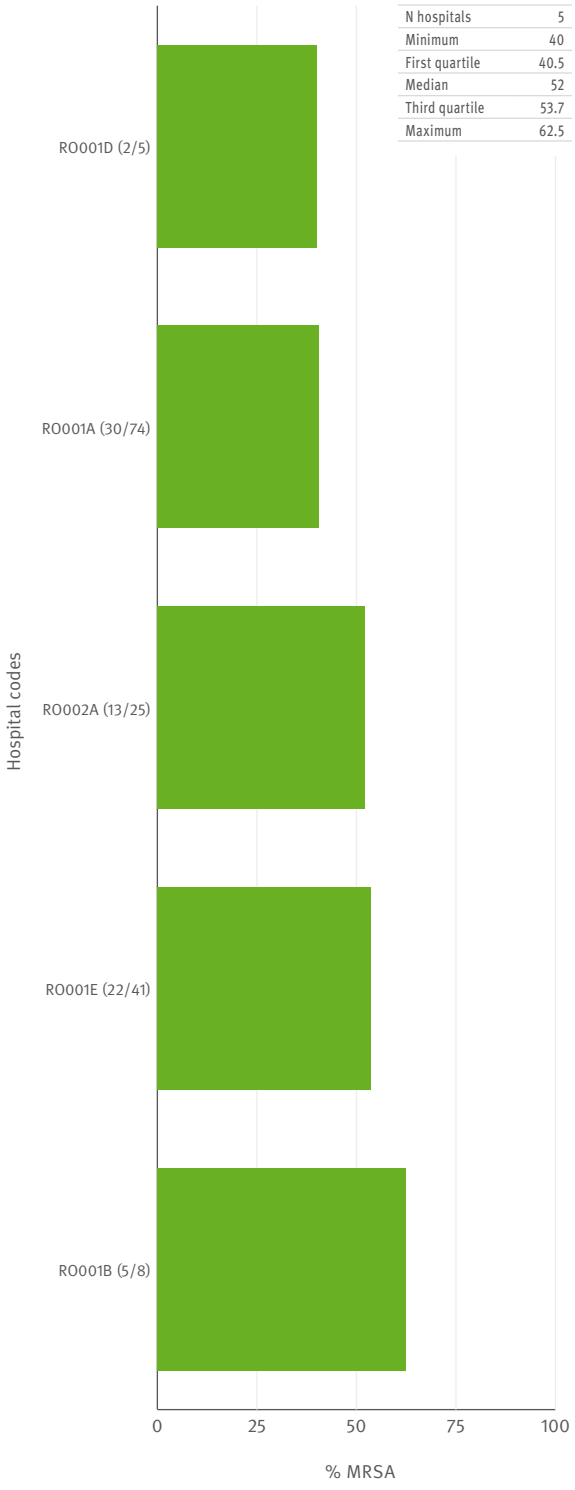


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

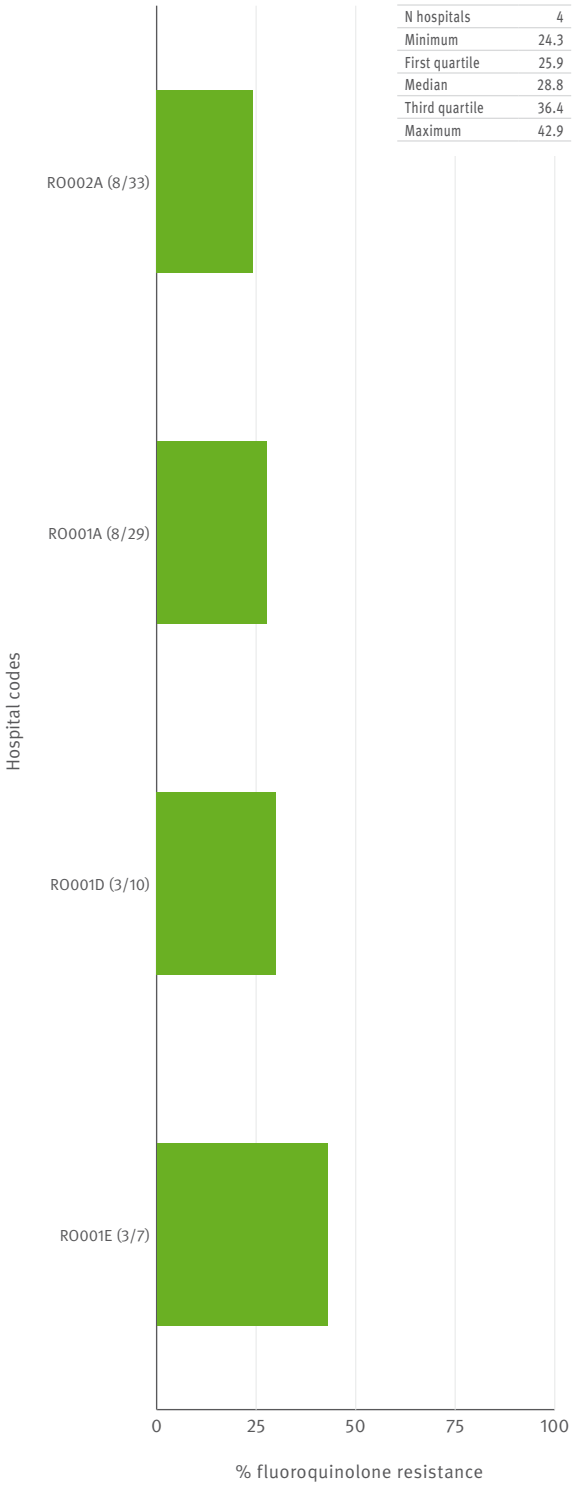
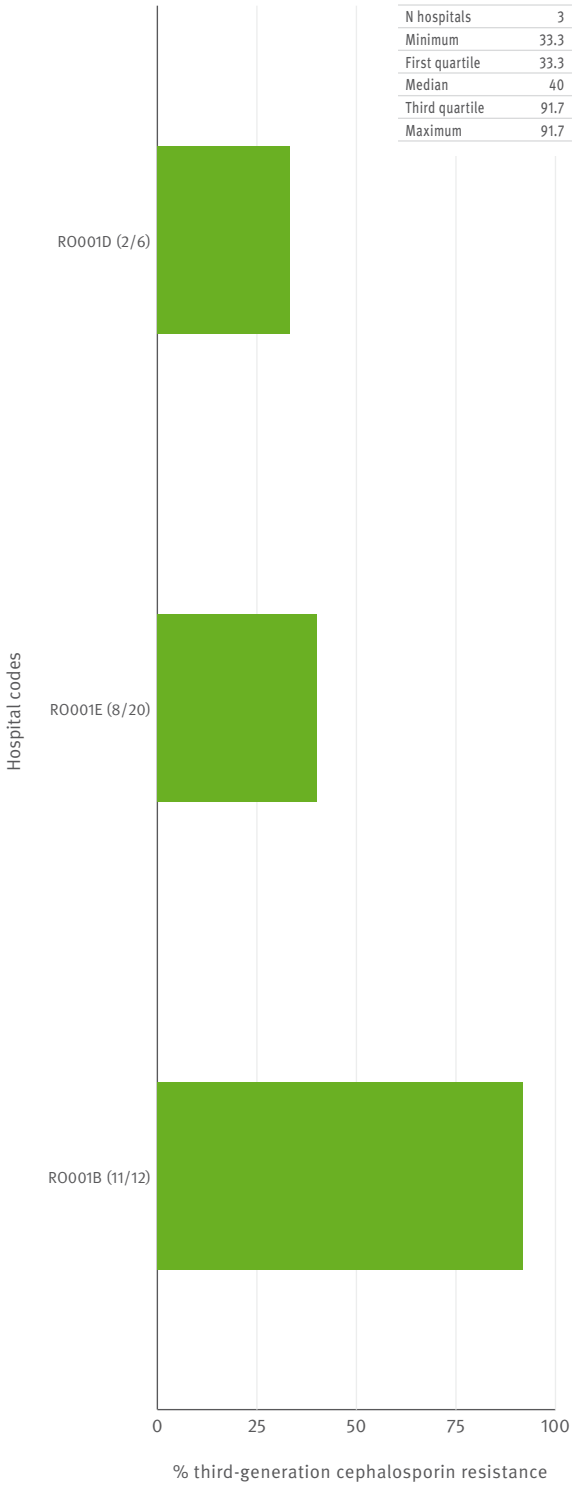


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Slovakia

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	14	27	16	269	16	239	10	75	-	-	-	-
2004	9	17	15	289	15	310	12	82	-	-	-	-
2005	4	8	12	147	13	134	8	46	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-	-	-	-
2011	7	26	11	565	11	738	11	302	11	463	11	265

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	4	24	<1	-	-	-	-	-	4
Penicillin RI	11	29	<1	-	-	-	-	-	8
Macrolides RI	<1	33	40	-	-	-	-	-	12
Staphylococcus aureus									
Oxacillin/Meticillin R	8	14	16	-	-	-	-	-	26
Escherichia coli									
Aminopenicilins R	54	62	59	-	-	-	-	-	69
Aminoglycosides R	6	11	7	-	-	-	-	-	18
Fluoroquinolones R	20	24	14	-	-	-	-	-	42
Third-gen. cephalosporins R	<1	7	8	-	-	-	-	-	31
Carbapenems R	<1	<1	<1	-	-	-	-	-	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	7	7	-	-	-	-	-	2
HL Gentamicin R	35	37	40	-	-	-	-	-	49
Vancomycin R	<1	<1	<1	-	-	-	-	-	<1
Enterococcus faecium									
Aminopenicilins RI	92	91	100	-	-	-	-	-	96
HL Gentamicin R	60	45	33	-	-	-	-	-	79
Vancomycin R	<1	9	<1	-	-	-	-	-	4
Klebsiella pneumoniae									
Aminoglycosides R	-	-	-	-	-	-	-	-	66
Fluoroquinolones R	-	-	-	-	-	-	-	-	71
Third-gen. cephalosporins R	-	-	-	-	-	-	-	-	68
Carbapenems R	-	-	-	-	-	-	-	-	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	-	-	-	-	-	-	41
Ceftazidime R	-	-	-	-	-	-	-	-	25
Carbapenems R	-	-	-	-	-	-	-	-	31
Aminoglycosides R	-	-	-	-	-	-	-	-	51
Fluoroquinolones R	-	-	-	-	-	-	-	-	59

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	65	6	100	26	99	42	100	0	100	4	97	68	98	30
CSF	35	11	-	-	1	57	-	-	-	-	3	83	2	50
Gender														
Male	50	0	61	25	47	52	63	0	61	5	62	75	57	31
Female	50	15	39	27	53	33	37	0	39	3	38	57	43	30
Age (years)														
0–4	15	0	8	9	6	9	8	0	4	0	9	74	12	17
5–19	4	0	3	14	3	47	2	0			3	42	4	30
20–64	50	0	47	25	37	45	44	0	59	3	43	71	53	35
65 and over	31	25	42	32	54	43	47	0	37	5	45	65	31	29
Hospital department														
ICU	31	13	14	30	12	37	28	0	29	0	22	79	28	51
Internal med.	27	0	52	26	40	44	34	0	30	0	31	61	22	13
Surgery	-	-	10	36	10	45	12	0	9	11	10	65	8	35
Other	42	9	21	19	35	41	26	0	32	9	36	67	40	27
Unknown	-	-	3	28	3	36	2	0	1	0	2	75	2	0

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Slovakia

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

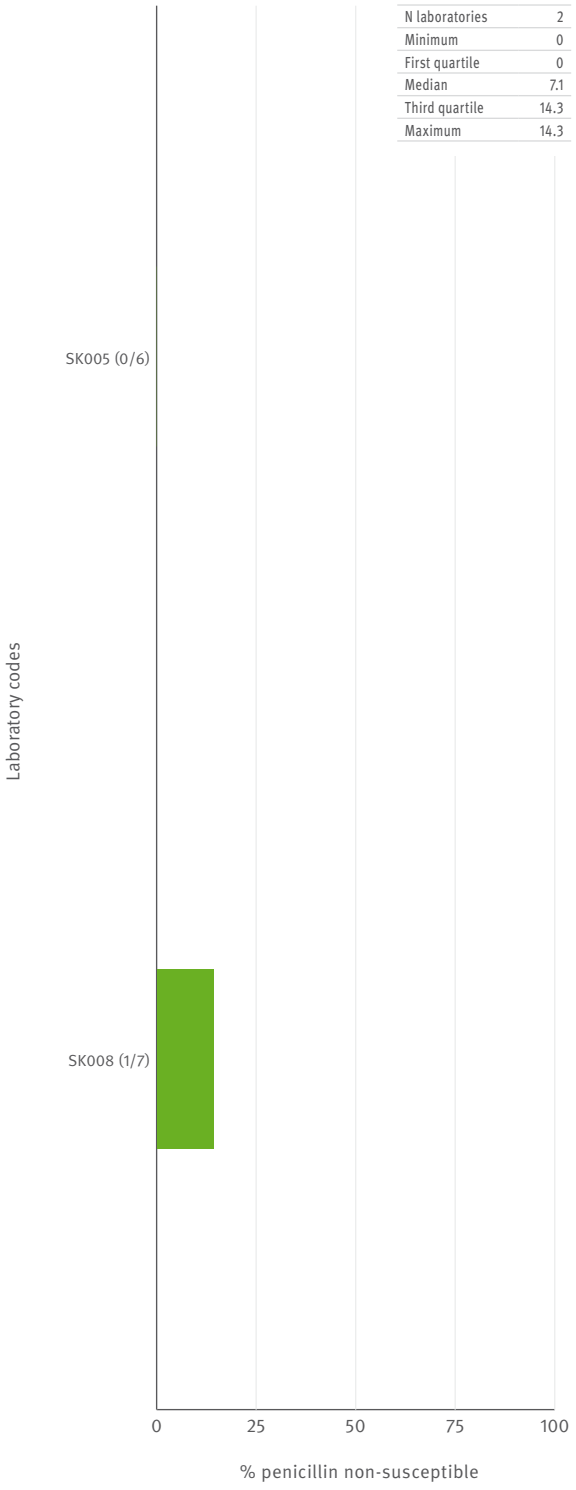


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

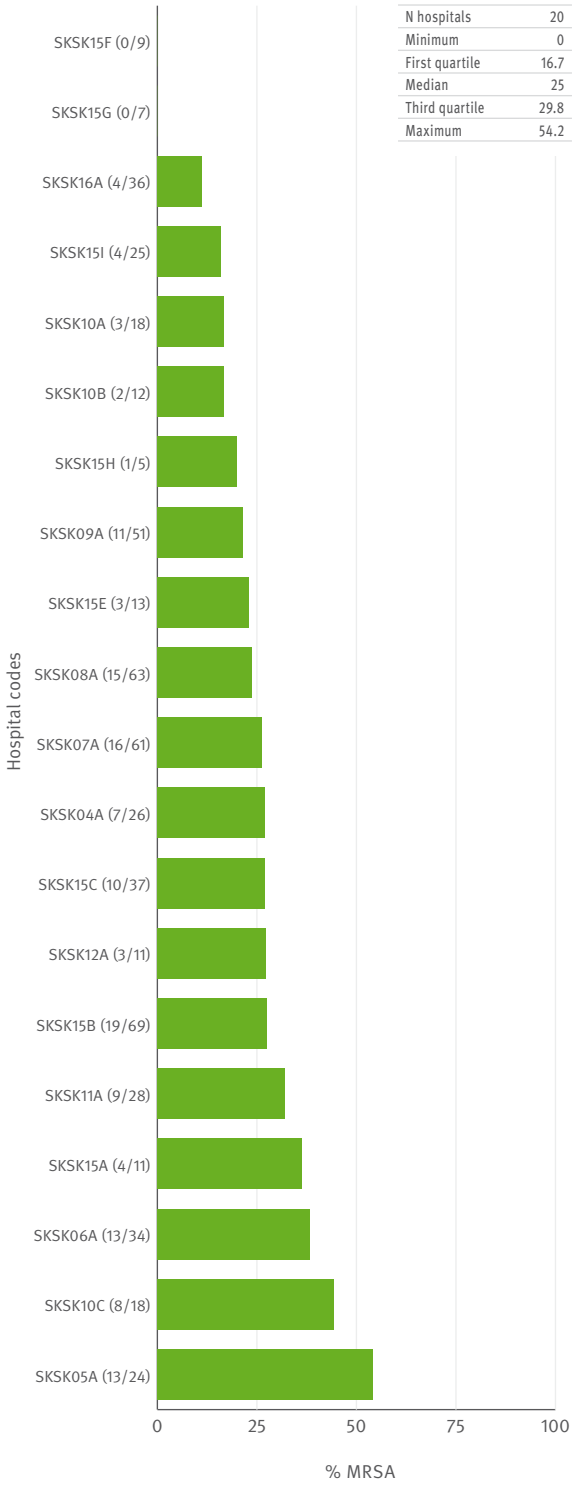


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

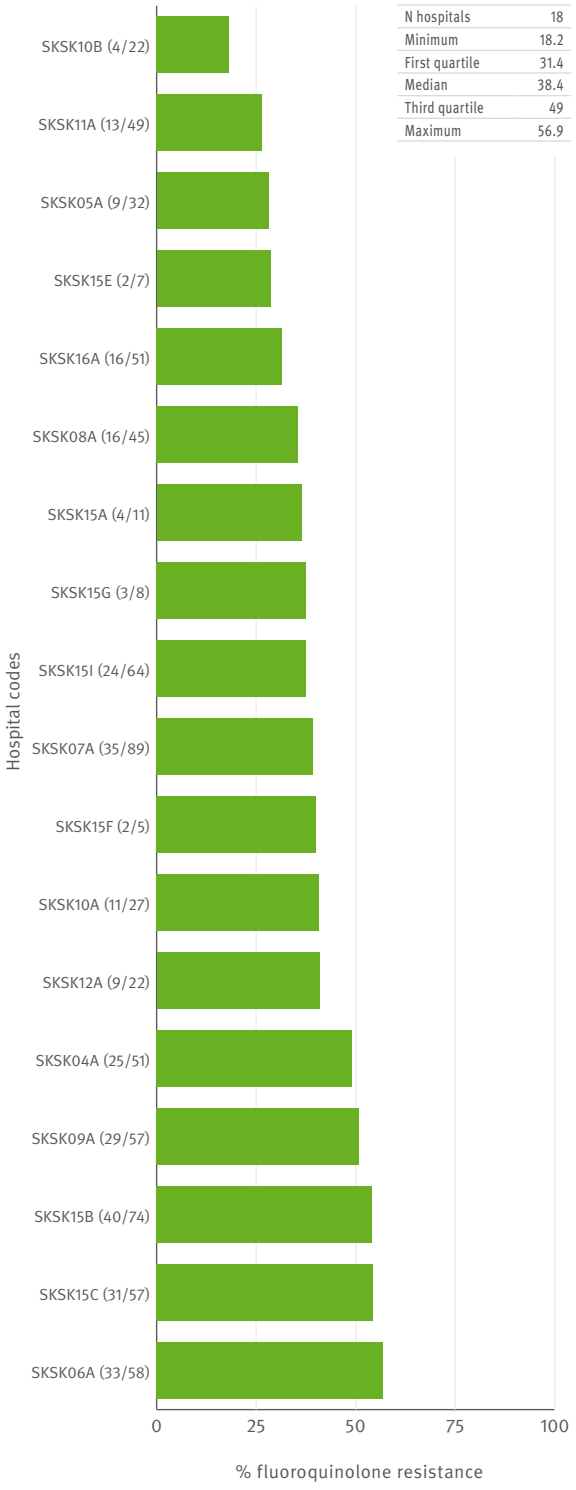
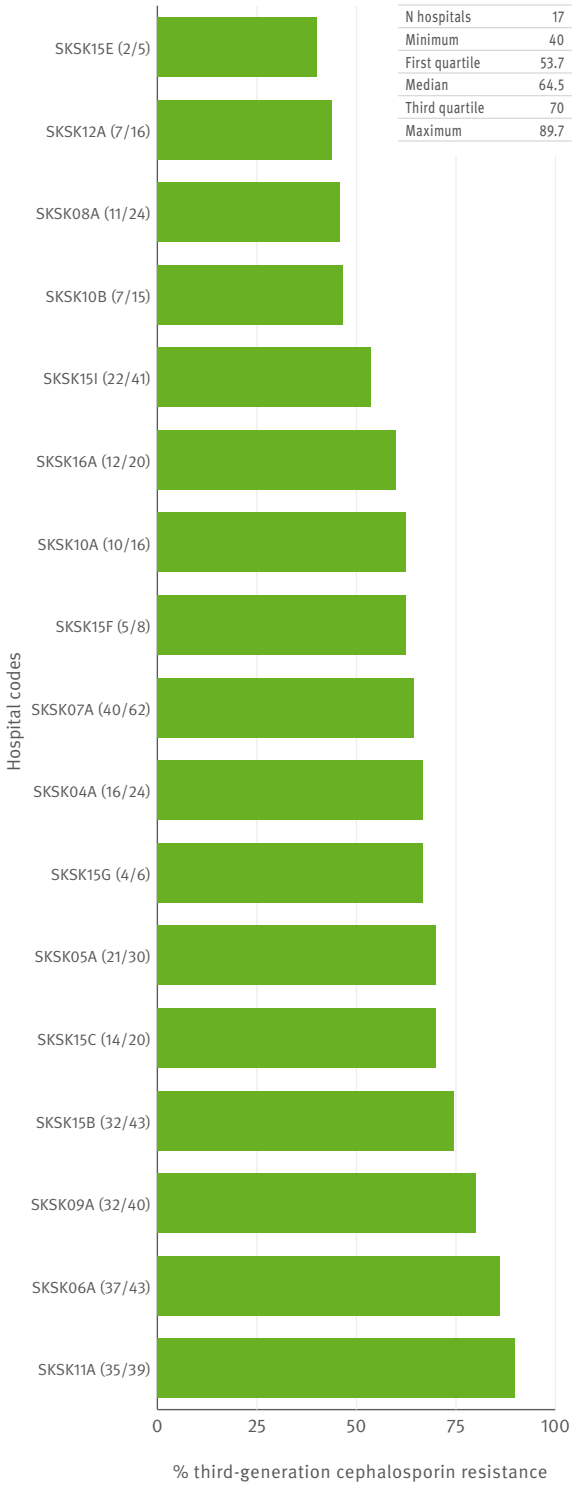


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Slovenia

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	11	172	11	299	11	401	10	76	-	-	-	-
2004	10	166	11	347	11	573	9	91	-	-	-	-
2005	11	208	11	349	11	657	11	119	10	78	8	38
2006	11	167	11	365	11	717	10	145	10	145	10	72
2007	10	195	10	422	10	851	9	183	10	170	9	88
2008	10	209	10	418	10	874	10	196	9	157	10	95
2009	10	253	10	471	10	893	10	198	10	189	10	107
2010	10	232	10	476	10	952	10	196	10	196	10	95
2011	10	253	10	464	10	1002	10	208	10	232	10	118

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	2	2	2	5	4	3	1	<1	<1
Penicillin RI	15	25	11	19	17	15	15	16	12
Macrolides RI	9	11	11	13	17	16	17	17	24
Staphylococcus aureus									
Oxacillin/Meticillin R	13	12	10	7	8	7	10	12	7
Escherichia coli									
Aminopenicilins R	41	40	42	44	49	49	53	48	54
Aminoglycosides R	2	5	4	7	7	7	10	9	10
Fluoroquinolones R	11	12	12	15	17	17	18	19	21
Third-gen. cephalosporins R	<1	1	2	2	4	4	5	7	9
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	<1	1	1	<1	<1	<1	2	<1
HL Gentamicin R	49	37	46	40	50	40	43	43	36
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	83	76	93	86	92	96	94	95	90
HL Gentamicin R	82	56	47	54	63	57	56	66	66
Vancomycin R	<1	<1	<1	6	5	13	4	2	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	17	19	24	23	28	23	22
Fluoroquinolones R	-	-	14	21	26	25	27	25	35
Third-gen. cephalosporins R	-	-	19	24	28	26	31	22	30
Carbapenems R	.	.	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	21	18	13	21	16	15	13
Ceftazidime R	-	-	11	8	7	14	8	5	8
Carbapenems R	-	-	13	6	19	16	15	19	24
Aminoglycosides R	-	-	18	15	10	13	12	9	8
Fluoroquinolones R	-	-	29	21	17	24	13	9	9

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	94	14	100	10	100	20	100	0	100	1	98	26	98	22
CSF	6	11	-	-	<1	25	-	-	-	-	2	75	2	25
Gender														
Male	56	15	63	10	43	24	63	0	57	0	61	29	65	25
Female	44	13	37	9	57	17	37	0	43	2	39	22	35	15
Age (years)														
0–4	22	17	2	0	2	2	3	0	3	0	3	0	2	20
5–19	2	0	3	0	1	0	1	0	1	0	2	13	2	25
20–64	37	12	40	10	25	21	25	0	46	0	33	28	35	33
65 and over	39	15	55	10	72	20	72	0	50	1	63	27	60	15
Hospital department														
ICU	15	4	13	20	10	20	17	0	30	0	21	37	27	41
Internal med.	36	15	40	8	49	19	35	0	27	0	35	16	27	14
Surgery	1	33	12	14	6	21	16	0	13	5	13	41	14	13
Other	49	15	35	6	36	22	32	0	29	0	31	26	31	15

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Slovenia

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

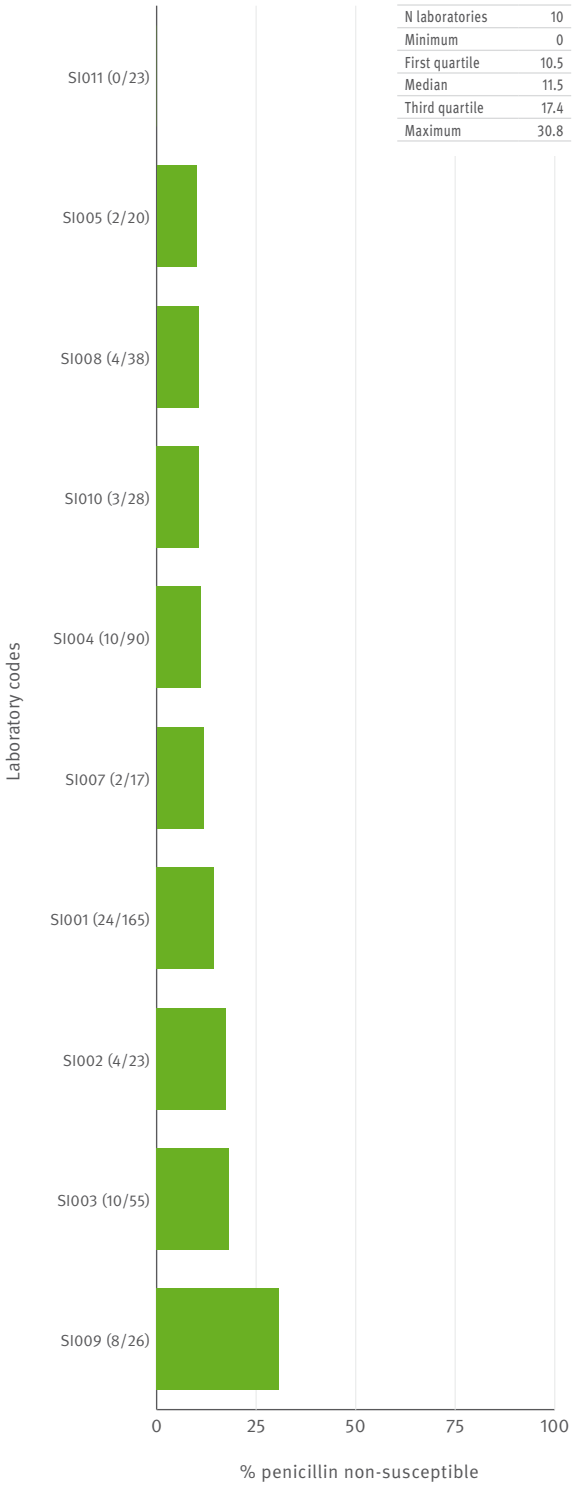


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

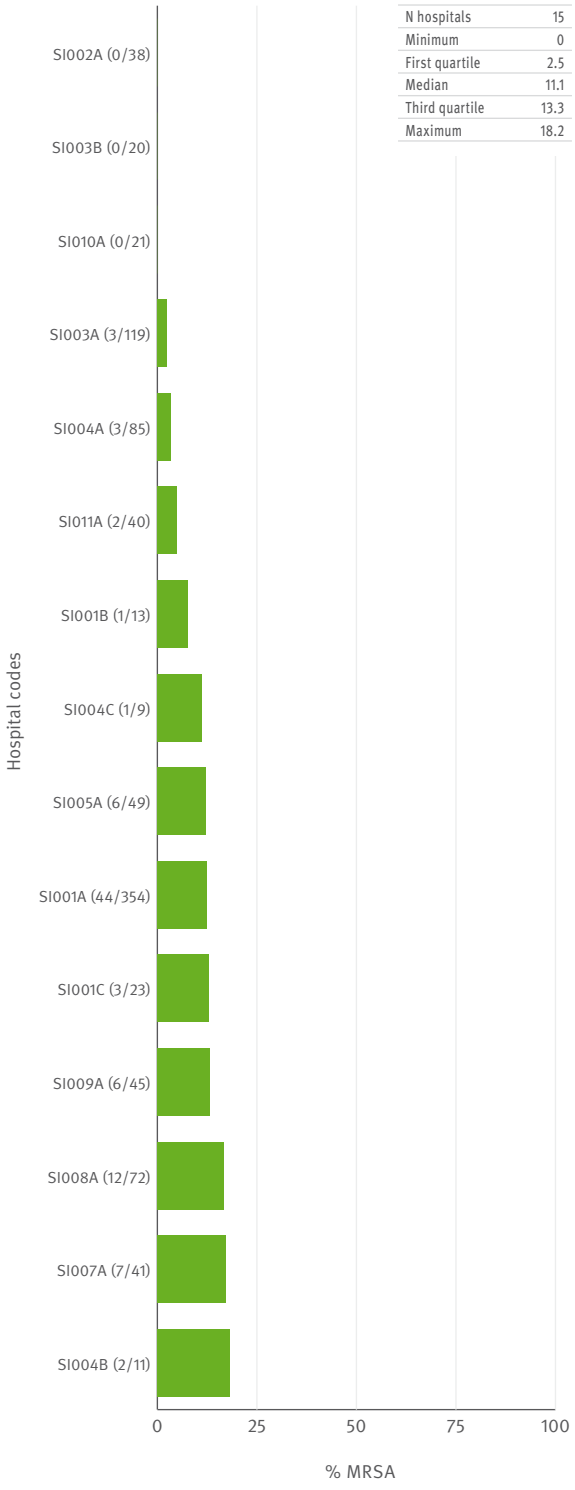


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

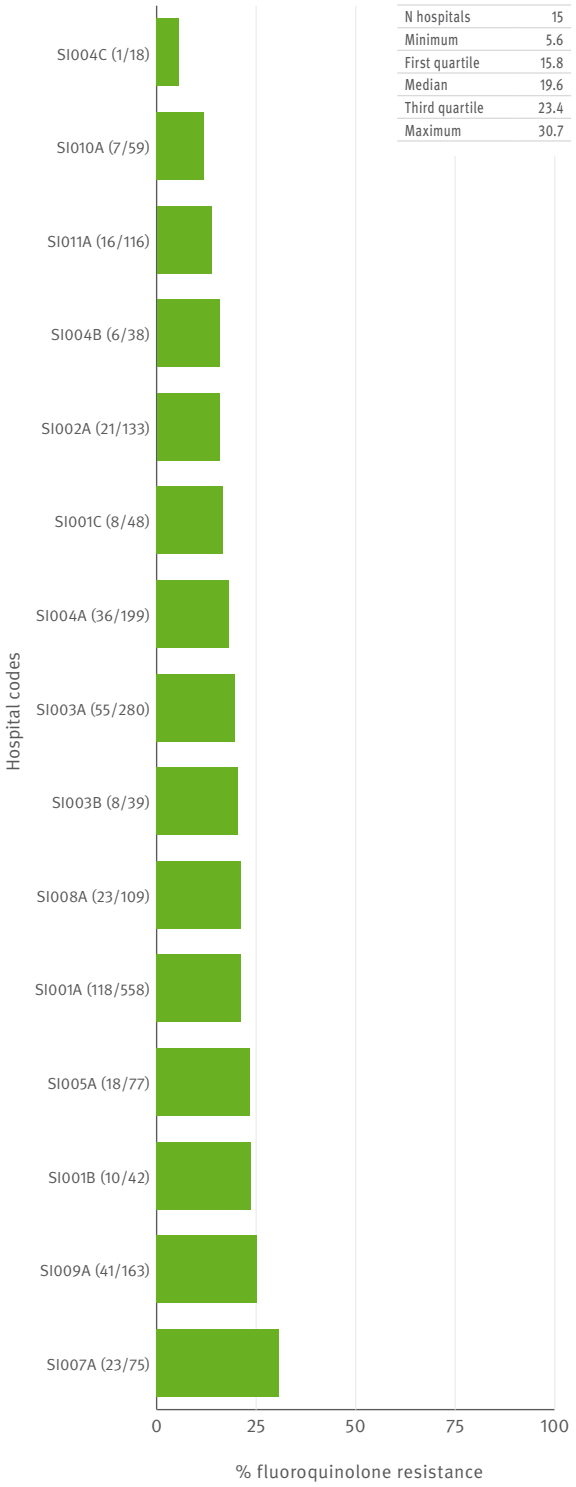
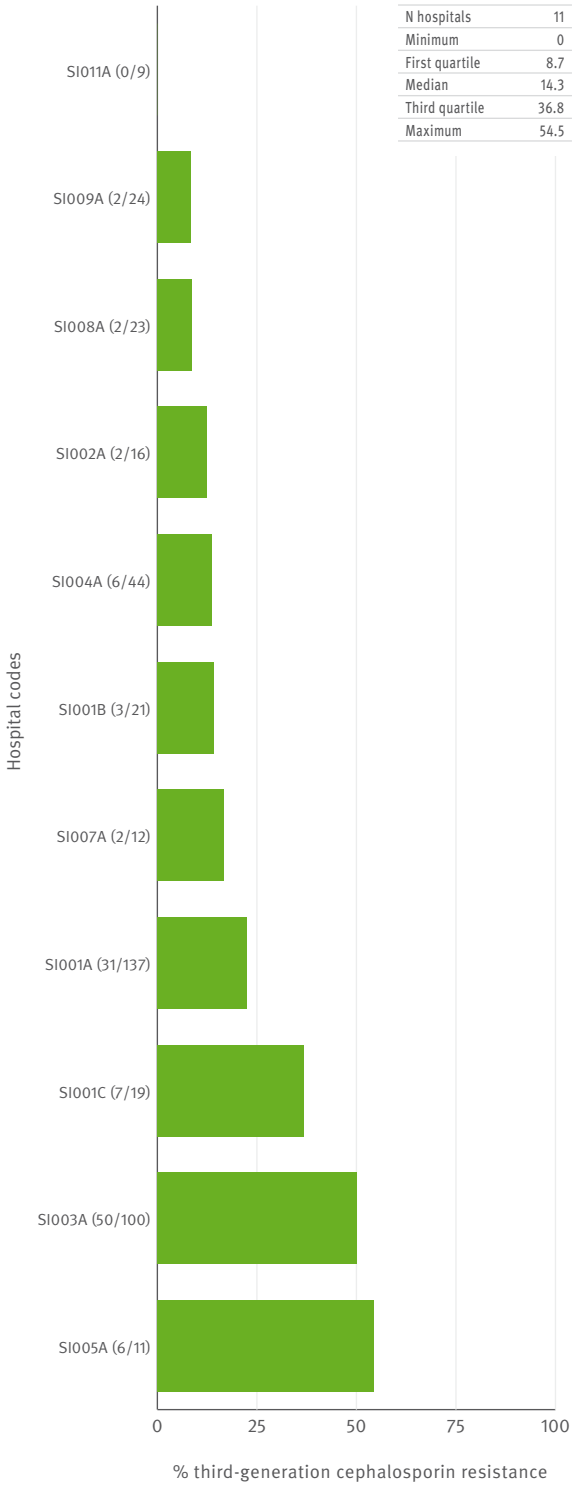


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Spain

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	35	656	36	1391	29	2650	36	608	-	-	-	-
2004	36	684	36	1527	36	3471	36	710	-	-	-	-
2005	34	740	34	1337	34	2997	35	623	14	56	13	70
2006	35	625	35	1483	35	3364	34	755	33	564	32	405
2007	35	862	35	1645	35	3678	35	885	33	618	35	448
2008	31	695	32	1505	32	3626	32	1002	30	639	32	548
2009	32	708	33	1715	33	3821	33	1093	32	628	33	544
2010	41	862	41	1986	41	5696	41	1467	41	1161	41	749
2011	40	763	40	1965	40	5605	39	1478	40	1145	40	839

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	7	9	9	8	8	7	8	10	10
Penicillin RI	32	29	25	27	22	23	22	30	30
Macrolides RI	27	27	23	22	18	22	19	27	25
Staphylococcus aureus									
Oxacillin/Meticillin R	24	26	27	25	25	27	26	25	22
Escherichia coli									
Aminopenicilins R	58	60	62	64	62	63	65	65	66
Aminoglycosides R	7	7	10	9	10	11	13	14	15
Fluoroquinolones R	21	25	28	28	30	33	31	33	34
Third-gen. cephalosporins R	4	7	8	7	7	9	11	12	12
Carbapenems R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	1	2	<1	2	1	3	3	1	<1
HL Gentamicin R	36	36	36	36	42	41	43	41	39
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	64	66	67	73	79	79	83	83	82
HL Gentamicin R	11	17	16	21	40	35	38	27	23
Vancomycin R	3	2	3	3	2	1	3	1	1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	4	7	9	9	9	9	10
Fluoroquinolones R	-	-	11	8	17	15	16	14	17
Third-gen. cephalosporins R	-	-	7	9	10	12	11	10	13
Carbapenems R	.	.	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	4	9	8	8	8	6	6
Ceftazidime R	-	-	6	7	10	11	8	7	9
Carbapenems R	-	-	17	12	15	13	16	18	16
Aminoglycosides R	-	-	4	11	15	18	19	18	19
Fluoroquinolones R	-	-	14	19	25	23	25	25	24

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	92	30	100	24	100	34	100	0	100	1	99	12	98	17
CSF	8	32	-	-	<1	13	-	-	-	-	1	4	2	19
Gender														
Male	59	29	63	24	52	38	63	0	63	1	60	13	68	17
Female	39	31	36	24	47	29	35	1	36	2	39	10	32	17
Unknown	1	32	1	31	1	44	1	0	1	0	2	14	<1	14
Age (years)														
0–4	14	40	6	15	4	10	15	0	5	0	8	11	4	14
5–19	4	26	3	8	1	29	1	0	1	0	1	8	2	24
20–64	37	25	34	18	28	30	30	0	32	1	34	13	36	23
65 and over	43	32	56	29	66	37	53	0	62	2	56	11	57	13
Unknown	2	13	1	20	1	28	0	0	0	0	1	17	1	9
Hospital department														
ICU	14	28	10	20	7	34	16	0	16	1	12	13	22	27
Internal med.	33	31	48	27	39	38	36	0	42	2	37	11	39	14
Surgery	1	24	9	32	7	32	10	1	14	1	11	17	9	18
Other	49	30	28	17	43	29	33	0	21	1	33	9	27	13
Unknown	3	33	5	21	5	39	6	0	6	0	6	22	4	15

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Spain

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

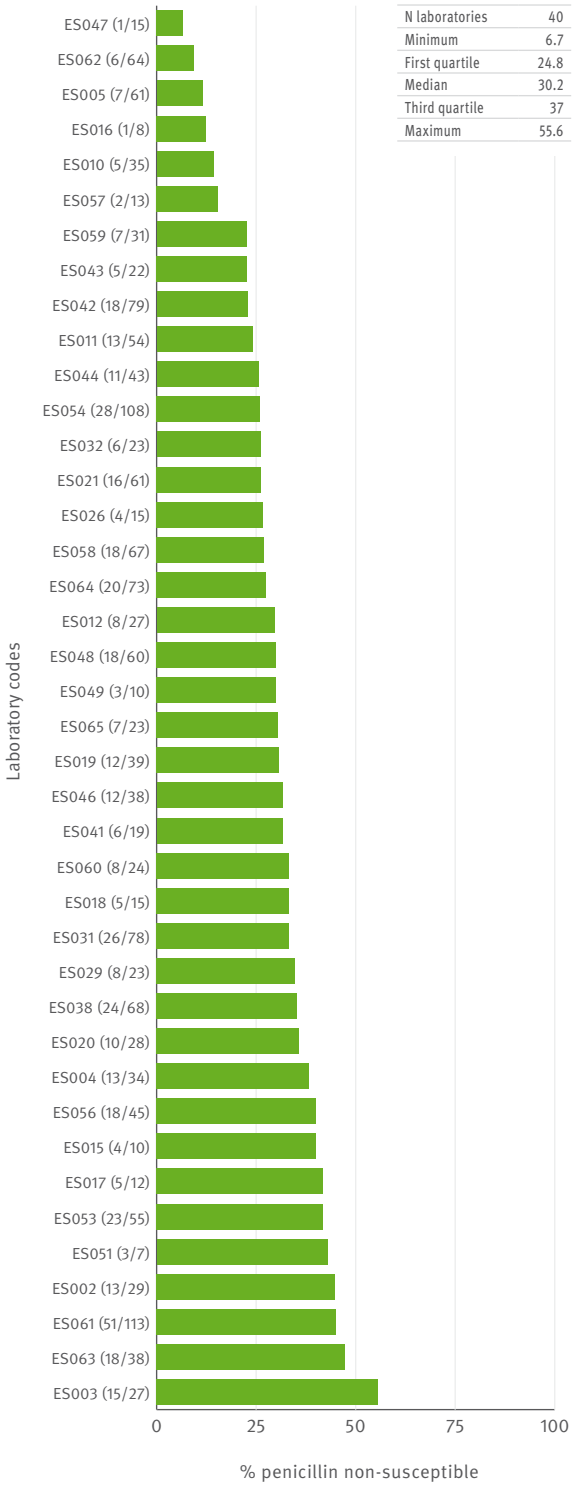


Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

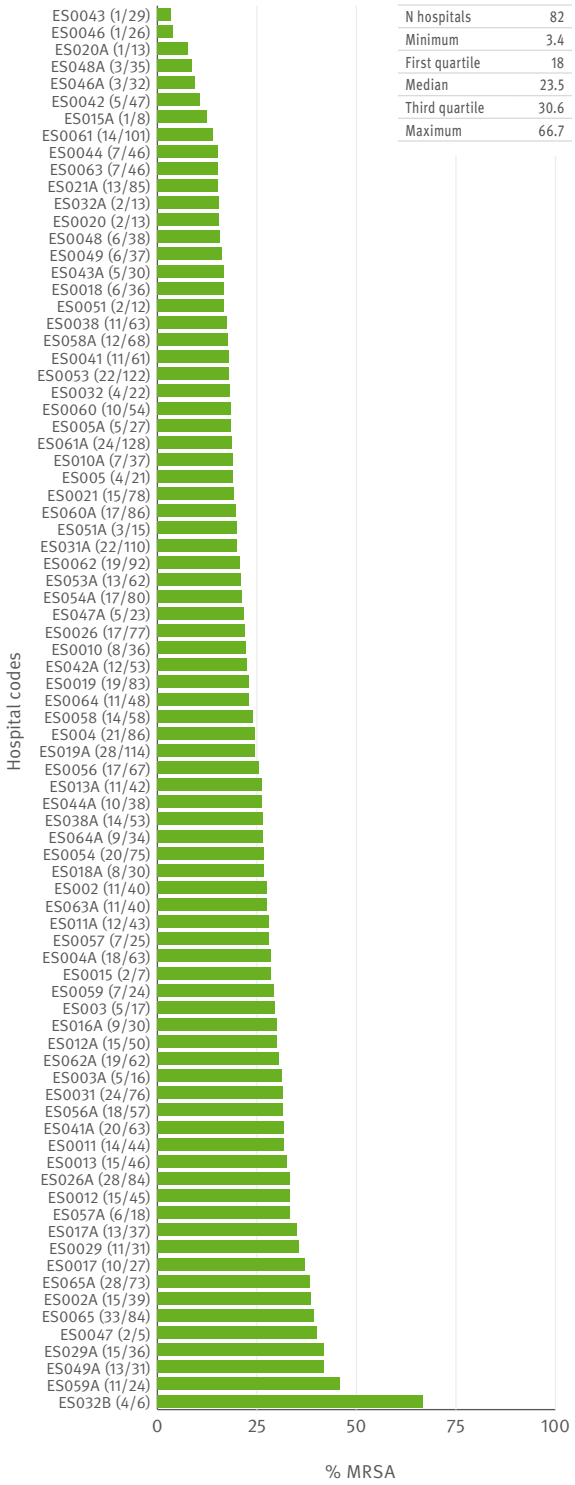


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

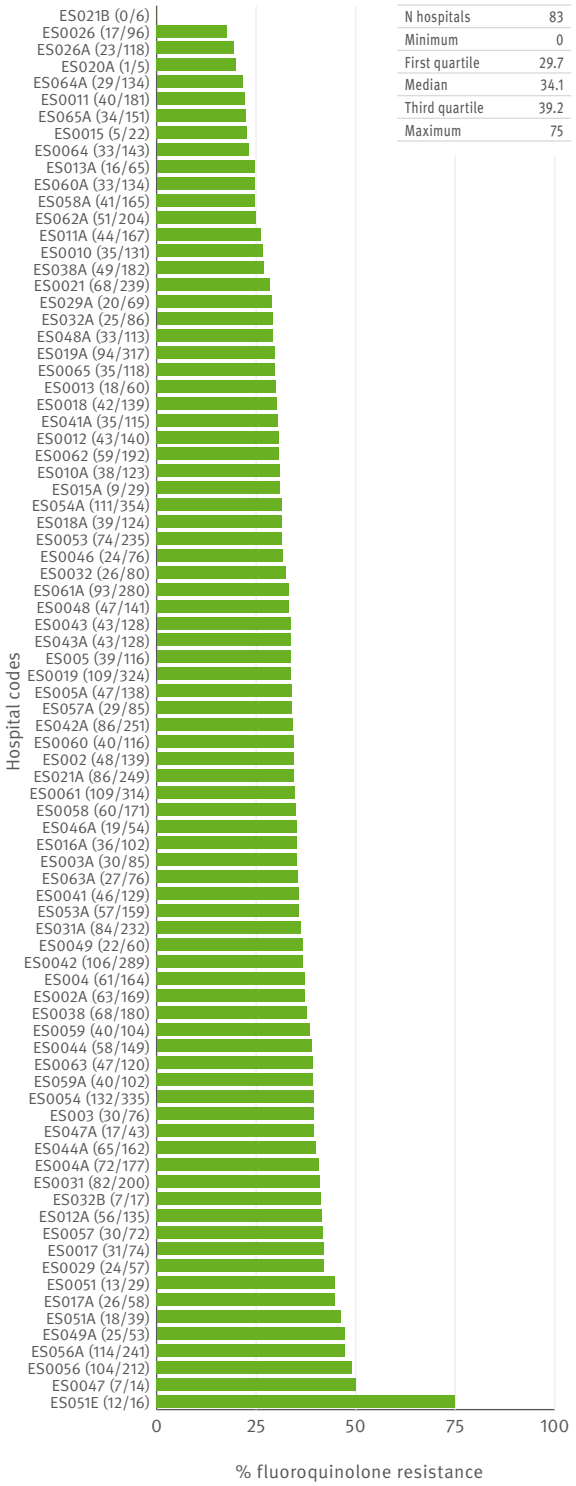
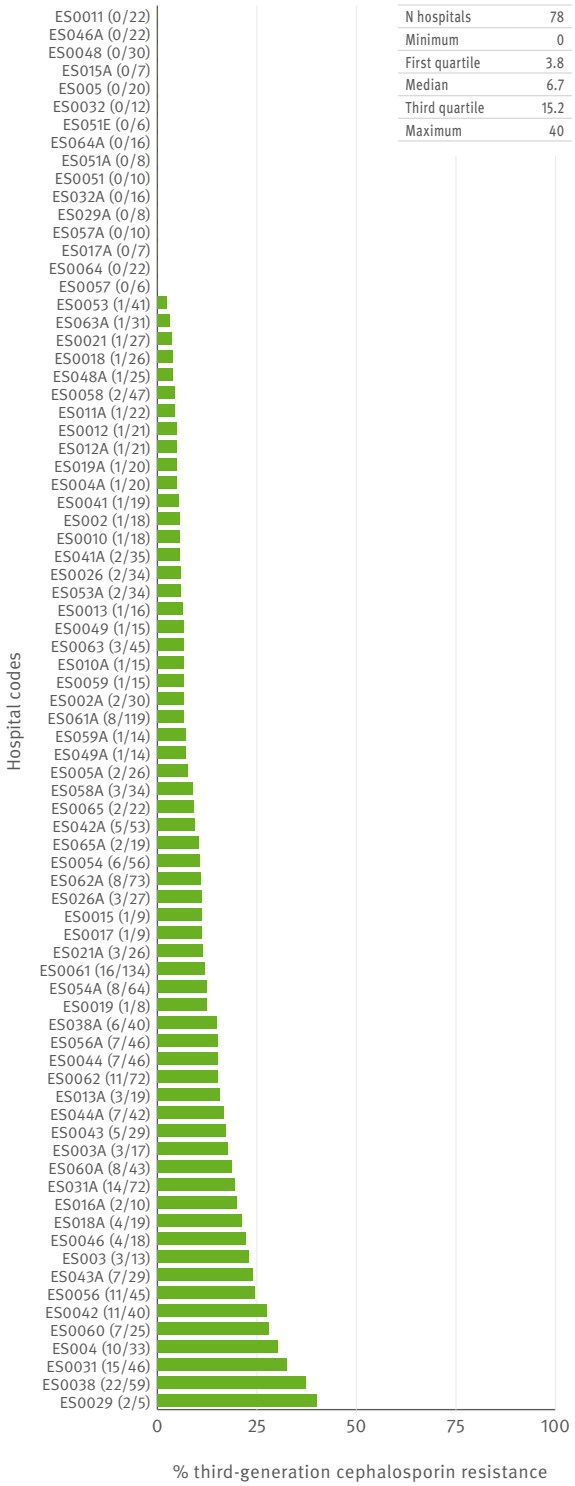


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



Sweden

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	21	919	21	1855	21	3350	21	850	-	-	-	-
2004	21	955	21	1906	21	3372	21	856	-	-	-	-
2005	21	1025	21	1774	21	3241	21	821	18	282	17	149
2006	21	996	21	1968	20	3539	21	884	20	621	18	300
2007	21	1032	21	2163	20	3749	21	932	20	649	20	343
2008	21	1219	21	2410	20	4032	21	1059	20	826	20	315
2009	19	1063	19	2460	18	4247	19	967	18	706	18	338
2010	19	1008	19	2867	18	4846	18	1038	18	878	18	377
2011	18	1015	18	3113	17	5253	18	1239	17	966	17	412

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	<1	<1	<1	<1	<1	<1	2	2	3
Penicillin RI	5	3	4	2	3	2	3	4	3
Macrolides RI	5	5	6	5	5	6	4	4	5
Staphylococcus aureus									
Oxacillin/Meticillin R	<1	<1	1	<1	<1	<1	1	<1	<1
Escherichia coli									
Aminopenicilins R	29	23	26	28	33	32	33	35	35
Aminoglycosides R	1	1	1	2	2	2	3	3	4
Fluoroquinolones R	7	8	6	8	10	10	8	11	8
Third-gen. cephalosporins R	<1	<1	1	2	2	2	3	3	3
Carbapenems R	.	.	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	<1	<1	<1	<1	<1	<1	<1	<1	1
HL Gentamicin R	17	16	19	20	16	20	19	15	19
Vancomycin R	<1	<1	<1	<1	<1	<1	<1	<1	<1
Enterococcus faecium									
Aminopenicilins RI	77	78	74	76	79	82	76	82	89
HL Gentamicin R	11	7	4	12	14	25	24	22	32
Vancomycin R	2	1	<1	<1	<1	2	<1	<1	<1
Klebsiella pneumoniae									
Aminoglycosides R	-	-	1	<1	1	1	<1	1	2
Fluoroquinolones R	-	-	5	5	6	7	2	5	2
Third-gen. cephalosporins R	-	-	1	1	1	2	2	2	2
Carbapenems R	.	.	<1	<1	<1	<1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	9	<1	2	1	2	1	4
Ceftazidime R	-	-	5	6	4	5	7	3	5
Carbapenems R	-	-	18	5	7	4	8	4	8
Aminoglycosides R	-	-	<1	<1	<1	<1	<1	<1	<1
Fluoroquinolones R	-	-	6	5	6	5	7	6	6

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	98	4	100	1	100	9	100	0	100	0	100	2	100	6
CSF	2	5	-	-	0	0	-	-	-	-	-	-	-	-
Gender														
Male	53	4	63	1	50	12	73	0	61	0	60	3	69	6
Female	47	3	37	1	50	6	27	0	39	0	40	1	31	6
Age (years)														
0–4	3	5	4	0	1	8	3	0	2	0	1	0	2	14
5–19	2	3	3	1	1	12	1	0	2	0	1	8	3	8
20–64	40	3	30	1	23	12	23	0	29	0	25	3	25	7
65 and over	54	4	63	1	73	8	72	0	65	0	72	2	69	6
Unknown	1	5	1	0	2	8	1	0	1	0	1	0	1	13
Hospital department														
ICU	6	3	4	1	3	8	6	0	12	0	4	6	5	15
Internal med.	36	3	34	0	32	7	28	0	24	0	27	2	32	5
Surgery	3	7	12	0	15	10	20	0	26	0	21	0	13	3
Other	49	4	44	1	39	10	40	0	34	0	39	3	44	6
Unknown	6	3	7	1	11	7	7	0	4	0	9	2	6	12

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

Sweden

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)

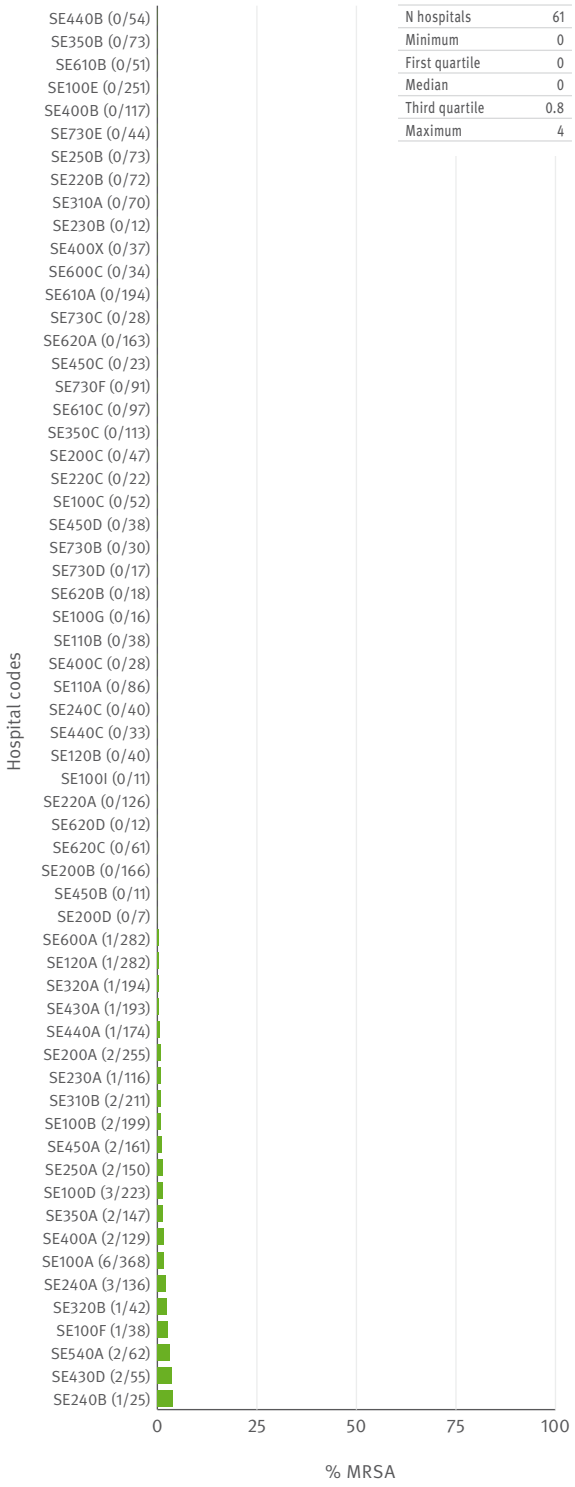


Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

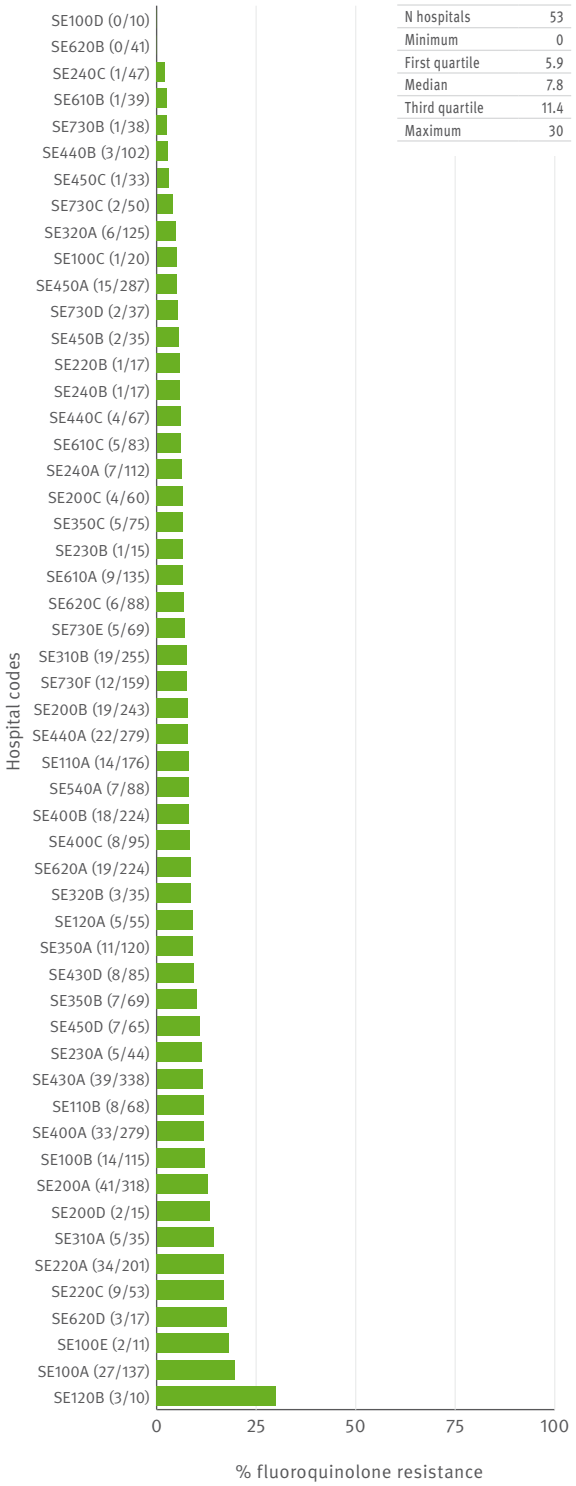
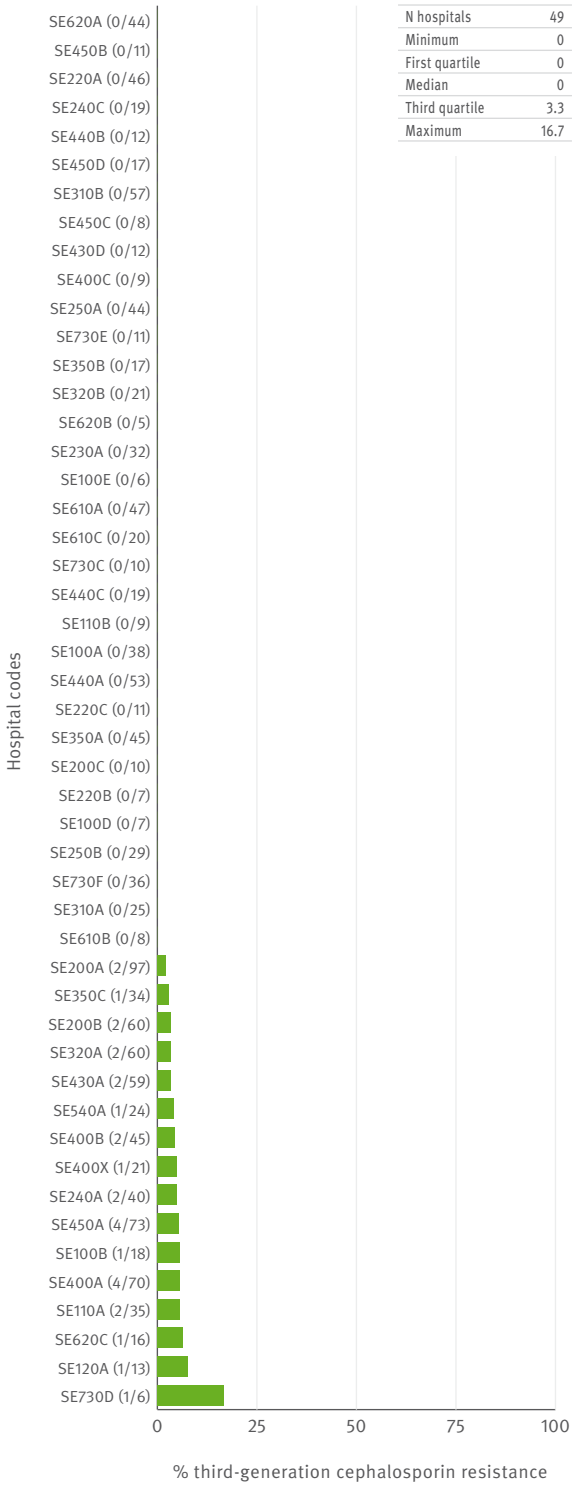


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



United Kingdom

General information about EARS-Net participating laboratories

Table 1: Annual number of reporting laboratories and number of reported isolates, 2003–2011

Year	*S. pneumoniae*		*S. aureus*		*E. coli*		Enterecocci		*K. pneumoniae*		*P. aeruginosa*	
	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates	Labs	Isolates
2003	50	1334	51	3548	19	2253	-	-	-	-	-	-
2004	54	1059	54	3562	20	2091	-	-	-	-	-	-
2005	53	1375	58	3971	23	2359	27	591	23	420	25	438
2006	51	1514	55	4132	26	2438	22	547	22	404	24	353
2007	50	1785	55	4865	20	2374	18	435	18	382	19	370
2008	51	1223	55	3355	15	2456	14	274	15	350	14	345
2009	59	1396	69	2977	28	4712	26	712	27	725	26	639
2010	50	1459	55	2730	29	5389	28	651	28	840	28	588
2011	53	1513	53	3430	29	5971	28	723	28	1007	28	599

Antibiotic resistance from 2003 to 2011

Table 2: Annual percentage (%) of antimicrobial non-susceptible and resistant isolates, 2003–2011

Pathogens by antimicrobial classes	2003	2004	2005	2006	2007	2008	2009	2010	2011
Streptococcus pneumoniae									
Penicillin R	1	<1	2	<1	2	1	1	<1	<1
Penicillin RI	5	3	4	3	4	5	3	3	5
Macrolides RI	13	13	11	12	10	6	4	5	6
Staphylococcus aureus									
Oxacillin/Meticillin R	44	44	44	42	36	31	28	22	14
Escherichia coli									
Aminopenicilins R	55	53	56	57	55	61	62	62	63
Aminoglycosides R	4	6	8	7	7	7	7	8	8
Fluoroquinolones R	11	14	17	20	18	15	18	17	18
Third-gen. cephalosporins R	3	3	6	8	9	7	9	9	10
Carbapenems R	-	-	-	<1	<1	<1	<1	<1	<1
Enterococcus faecalis									
Aminopenicilins RI	-	-	2	3	4	2	2	6	4
HL Gentamicin R	-	-	47	52	31	42	38	39	16
Vancomycin R	-	-	2	1	2	4	2	1	2
Enterococcus faecium									
Aminopenicilins RI	-	-	84	78	82	83	91	84	90
HL Gentamicin R	-	-	53	18	35	7	38	31	56
Vancomycin R	-	-	33	18	21	28	13	10	9
Klebsiella pneumoniae									
Aminoglycosides R	-	-	6	8	9	6	5	5	4
Fluoroquinolones R	-	-	12	13	12	7	6	7	5
Third-gen. cephalosporins R	-	-	12	11	13	7	7	10	5
Carbapenems R	-	-	<1	<1	<1	1	<1	<1	<1
Pseudomonas aeruginosa									
Piperacillin (± tazobactam) R	-	-	2	1	5	2	3	4	4
Ceftazidime R	-	-	3	3	7	4	5	5	5
Carbapenems R	-	-	9	6	10	6	8	6	6
Aminoglycosides R	-	-	3	3	5	3	1	2	3
Fluoroquinolones R	-	-	8	8	9	8	7	7	6

Demographic characteristics

Table 3: Selected details on invasive isolates reported for 2010 and 2011

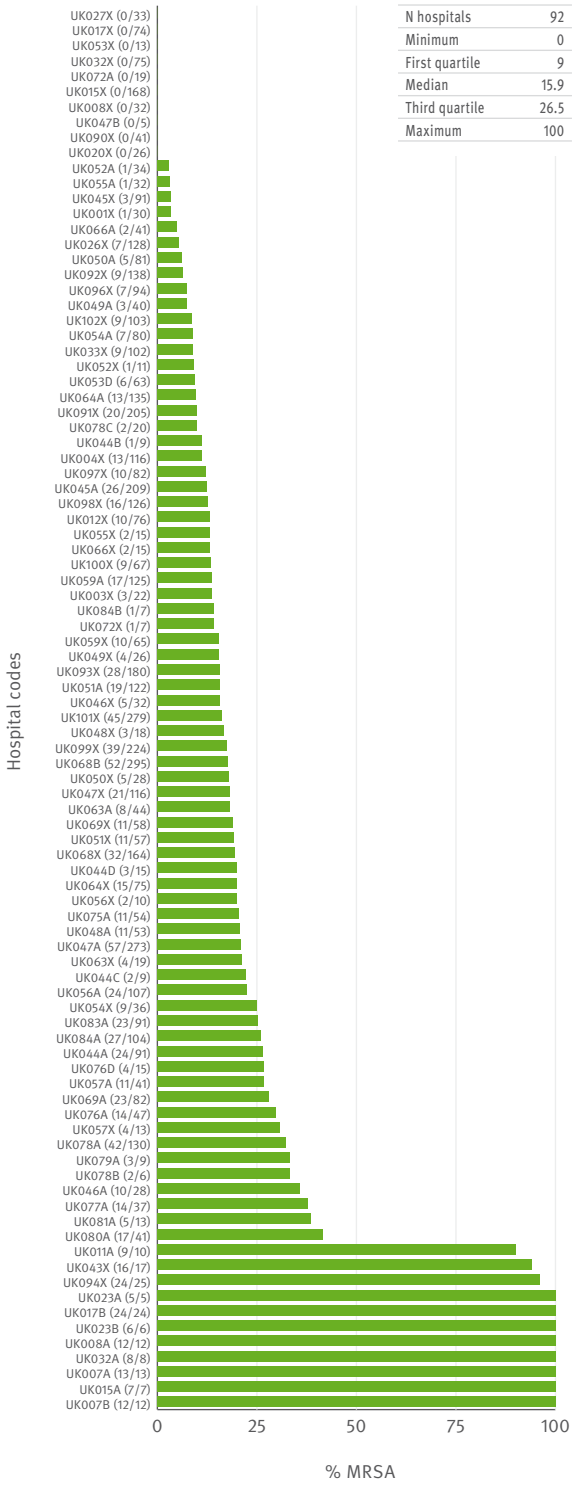
Characteristic	*S. pneumoniae*		*S. aureus*		*E. coli*		*E. faecalis*		*E. faecium*		*K. pneumoniae*		*P. aeruginosa*	
	% total	% PNSP	% total	% MRSA	% total	% FREC	% total	% VRE	% total	% VRE	% total	% 3GCRKP	% total	% CRPA
Isolate source														
Blood	99	4	100	17	100	17	100	2	100	10	100	7	100	6
CSF	1	7	-	-	-	-	-	-	-	-	-	-	-	-
Gender														
Male	51	4	61	18	48	20	65	0	63	8	59	8	61	6
Female	48	4	39	16	52	15	35	3	37	12	41	6	39	6
Unknown	1	0	<1	27	<1	11	1	25	0	0	<1	17	<1	50
Age (years)														
0–4	6	5	5	10	2	7	11	2	5	0	3	13	3	16
5–19	4	2	3	3	1	9	2	7	1	13	1	6	2	19
20–64	44	3	37	13	26	17	27	1	38	13	30	6	31	9
65 and over	46	5	47	24	71	18	60	1	53	8	66	8	63	4
Unknown	1	5	8	2	0	0	1	0	2	8	0	0	1	0
Hospital department														
ICU	4	2	4	20	-	-	-	-	-	-	-	-	-	-
Internal med.	13	6	12	26	-	-	-	-	-	-	-	-	-	-
Surgery	1	9	3	26	-	-	-	-	-	-	-	-	-	-
Other	24	4	24	20	-	-	-	-	-	-	-	-	-	-
Unknown	58	4	58	14	100	17	100	2	100	10	100	7	100	6

PNSP: penicillin-non-susceptible *S. pneumoniae*; MRSA: meticillin-resistant *S. aureus*; FREC: fluoroquinolone-resistant *E. coli*; VRE: vancomycin-resistant Enterococcus; 3GCRKP: third-generation cephalosporin-resistant *K. pneumoniae*; CRPA: carbapenem-resistant *P. aeruginosa*.

United Kingdom

Figure 1: *S. pneumoniae*: percentage (%) of invasive isolates with penicillin non-susceptibility by laboratory (2010–2011)

Figure 2: *S. aureus*: percentage (%) of invasive isolates with resistance to meticillin (MRSA) by hospital (2010–2011)



100% meticillin resistance rates for isolates of *S. aureus* reflect reporting of MRSA only.

Figure 3: *E. coli*: percentage (%) of invasive isolates with resistance to fluoroquinolones by hospital (2010–2011)

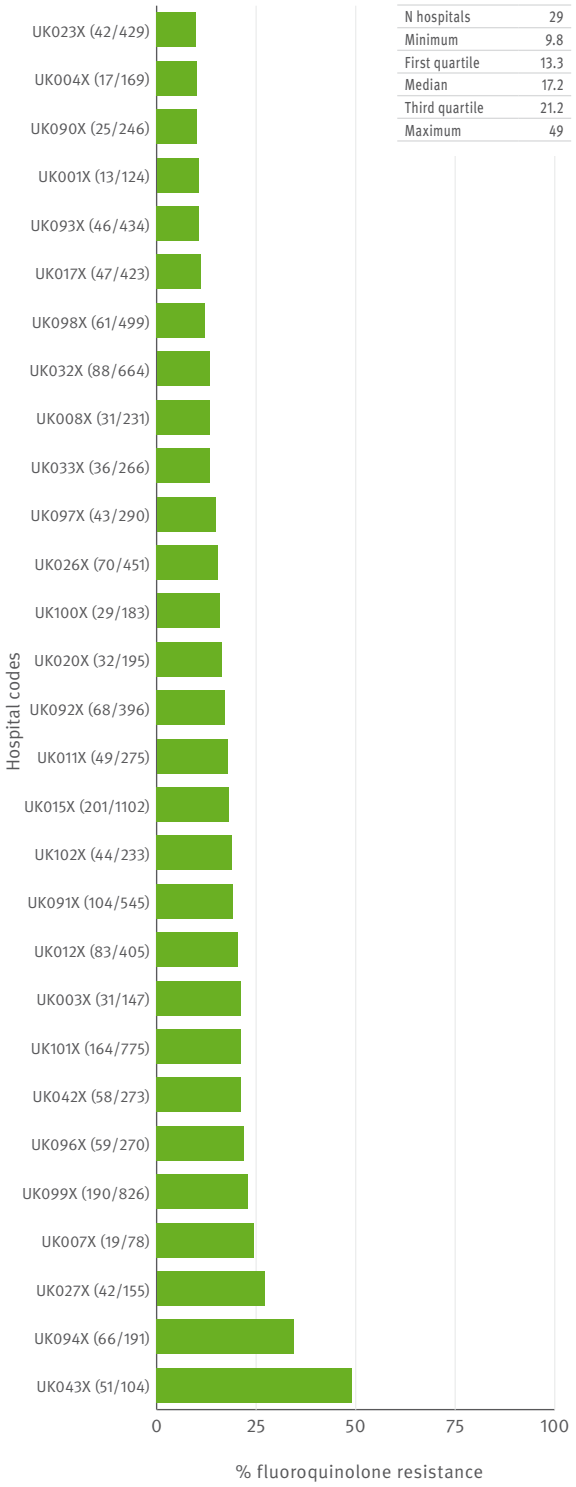
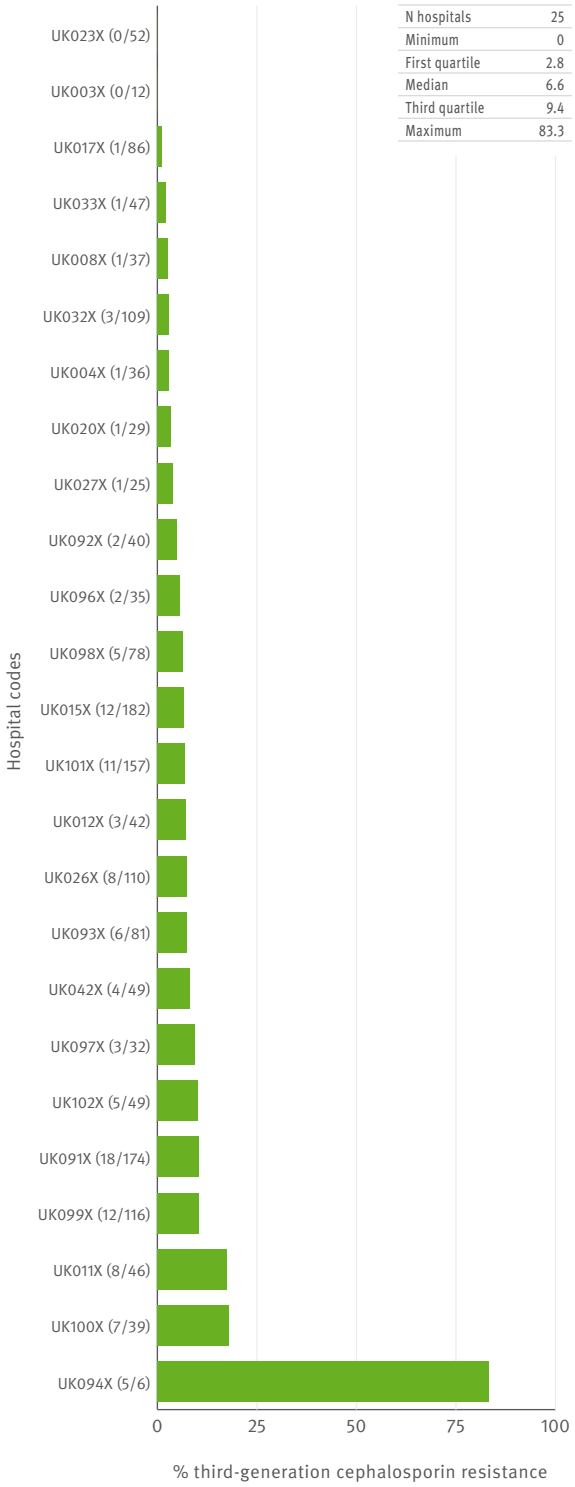


Figure 4: *K. pneumoniae*: percentage (%) of invasive isolates with resistance to third-generation cephalosporins by hospital (2010–2011)



HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- via EU Bookshop (http://bookshop.europa.eu);
- at the European Commission's representations or delegations. You can obtain their contact details on the Internet (http://ec.europa.eu) or by sending a fax to +352 2929-42758.

Priced publications:

- via EU Bookshop (http://bookshop.europa.eu).

Priced subscriptions (e.g. annual series of the Official Journal of the European Union and reports of cases before the Court of Justice of the European Union):

- via one of the sales agents of the Publications Office of the European Union(http://publications.europa.eu/others/agents/index_en.htm).

TQ-AM-12-001-EN-C

European Centre for Disease Prevention and Control (ECDC)

Postal address:
ECDC, 171 83 Stockholm, Sweden

Visiting address:
Tomtebodavägen 11A, Solna, Sweden

Phone +46 (0)8 58 60 1000
Fax +46 (0)8 58 60 1001
www.ecdc.europa.eu

An agency of the European Union
www.europa.eu

Publications Office