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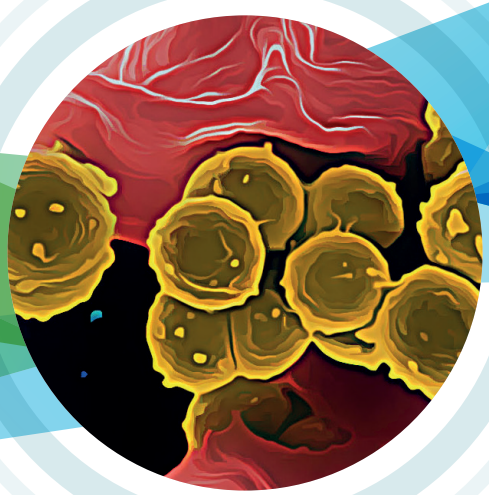

Antimicrobial resistance surveillance in Europe

2023

2021 data

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2021 data

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Contents

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Tables

Figures

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Abbreviations

AMR	antimicrobial resistance
AST	antimicrobial susceptibility testing
AWaRe (WHO)	Access, Watch, Reserve (classification system)
CAESAR	Central Asian and European Surveillance of Antimicrobial Resistance (network)
CCRE	carbapenem- and/or colistin-resistant Enterobacterales
CLSI	Clinical and Laboratory Standards Institute
CRE	carbapenem-resistant Enterobacterales
EARS-Net	European Antimicrobial Resistance Surveillance Network
ECDC	European Centre for Disease Prevention and Control
EEA	European Economic Area
EQA	external quality assessment
ESAC-Net	European Surveillance of Antimicrobial Consumption Network
ESCMID	European Society of Clinical Microbiology and Infectious Diseases
EUCAST	European Committee on Antimicrobial Susceptibility Testing
EU	European Union
EURGen-Net	European Antimicrobial Resistance Genes Surveillance Network
GAP-AMR	(WHO) Global Action Plan on Antimicrobial Resistance
GLASS	(WHO) Global Antimicrobial Resistance Surveillance System
HAI-Net	Healthcare-associated Infections Surveillance Network
I	susceptible, increased exposure
ICU	intensive care unit
IPC	infection prevention and control
LA-MRSA	livestock-associated meticillin-resistant *Staphylococcus aureus*
MIC	minimum inhibitory concentrations
MRSA	meticillin-resistant *Staphylococcus aureus*
NAP	national action plan
NPI	non-pharmaceutical intervention
PCR	polymerase chain reaction (test)
PCV	pneumococcal conjugated vaccine
R	resistant
RIVM	Netherlands National Institute for Public Health and the Environment
S	susceptible, standard dosing regimen

SARS-CoV-2	severe acute respiratory syndrome coronavirus 2
spp.	species
TESSy	The European Surveillance System
TrACSS	Tripartite Antimicrobial resistance Country Self-assessment Survey

Bacterial species

A. baumannii	*Acinetobacter baumannii*
***Acinetobacter* spp.**	*Acinetobacter* species
E. coli	*Escherichia coli*
E. faecalis	*Enterococcus faecalis*
E. faecium	*Enterococcus faecium*
K. pneumoniae	*Klebsiella pneumoniae*
P. aeruginosa	*Pseudomonas aeruginosa*
S. aureus	*Staphylococcus aureus*
S. pneumoniae	*Streptococcus pneumoniae*

Executive summary

WHO European Region

The results presented in this report are based on antimicrobial resistance (AMR) data from invasive isolates reported to the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network and the European Antimicrobial Resistance Surveillance Network (EARS-Net) in 2022 (data referring to 2021). In total, 16 countries reported data to CAESAR, while 29 countries, including all of those in the European Union (EU) and two from the European Economic Area (EEA) (Iceland and Norway), reported data to EARS-Net. Although the EARS-Net and CAESAR networks use comparable methods for data collection and analysis, the results presented in this report originate from distinct country surveillance systems. As these inherently are influenced by specific protocols and practices, caution is advised when comparing AMR patterns between countries.

Epidemiology

The AMR situation in bacterial species reported to the AMR surveillance networks referring to isolates obtained in 2021 varied widely depending on bacterial species, antimicrobial group and geographical region (see Fig. 1–10 in Chapter 3). Resistance to third-generation cephalosporins and carbapenems was generally higher in *Klebsiella pneumoniae* than *Escherichia coli*. While carbapenem resistance remained rare in *E. coli* for most countries, 33% of the countries reported resistance percentages of 25% or higher in *K. pneumoniae*. Carbapenem resistance was also common in *Pseudomonas aeruginosa* and *Acinetobacter* species, and at a higher percentage than in *K. pneumoniae*. As observed in previous regional reports, there is a north-to-south and west-to-east gradient of resistance, with higher rates observed in the southern and eastern parts of the European Region than in the northern and western parts. This was particularly evident for third-generation cephalosporin and carbapenem resistance in *K. pneumoniae* and carbapenem resistance in *Acinetobacter* spp.

Considering only the 13 countries that submitted data to CAESAR both in 2020 and 2021, the overall number of isolates reported was higher in 2021 than in 2020. This was a result of higher numbers of isolates being reported across all pathogens. These overall tendencies were not always observed at country level, however, all countries reported higher numbers of *Acinetobacter* spp. isolates in 2021 than in 2020. In all 16 countries submitting data to CAESAR in 2021, the majority of isolates (70.0%) were *E. coli* (37.9%), *Staphylococcus aureus* (17.2%) and *K. pneumoniae* (14.9%).

Looking at bacterial species-specific results in 2021, resistance to fluoroquinolones in *E. coli* was generally lowest in the northern parts of the WHO European Region and highest in the southern (see Fig. 1 in Chapter 3). A resistance percentage below 10% was observed in two (4%) of 45 countries reporting data on this microorganism. A resistance percentage of 25% or above was reported in 17 (38%) countries. A resistance percentage of 50% or above was observed in four (9%) countries. For third-generation cephalosporin resistance in *E. coli*, 12 (27%) of 45 countries reported percentages below 10%, whereas resistance percentages equal to or above 50% were observed in four (9%) (see Fig. 2 in Chapter 3). Eight (18%) of 44 countries reported carbapenem-resistant *E. coli* percentages of 1% or above (see Fig. 3 in Chapter 3).

Third-generation cephalosporin resistance in *K. pneumoniae* has become quite widespread in the WHO European Region. In 2021, percentages below 10% were observed in seven (16%) of 45 countries reporting data on this microorganism, while 19 (42%), particularly in the southern and eastern parts of the Region, reported resistance percentages of 50% or above (see Fig. 4 in Chapter 3). Carbapenem resistance was more frequently reported in *K. pneumoniae* than in *E. coli*. In 2021, resistance percentages were generally low in the northern and western parts of the WHO European Region; 14 (31%) of 45 countries reported resistance percentages below 1% (see Fig. 5 in Chapter 3). Fifteen (33%) countries reported percentages equal to or above 25%, eight of which (18% of 45 countries) reported resistance percentages equal to or above 50%.

Large differences were observed in the percentages of carbapenem-resistant *P. aeruginosa* in the European Region. In 2021, resistance percentages of under 5% were observed in two (5%) of 44 countries reporting data on this microorganism, whereas six (14%) countries reported percentages equal to or above 50% (see Fig. 6 in Chapter 3).

In 2021, the percentages of carbapenem-resistant *Acinetobacter* spp. varied widely within the Region, from below 1% in three (7%) of 45 countries reporting data on this microorganism to 50% or above in 25 (56%) countries, mostly in southern and eastern Europe (see Fig. 7 in Chapter 3).

In 2021, 11 (25%) of 44 countries reporting data on *S. aureus* had meticillin-resistant *S. aureus* (MRSA) percentages below 5% (see Fig. 8 in Chapter 3). MRSA percentages equal to or above 25% were observed in 13 (30%) of 44 countries.

Large differences were observed across the Region in the percentage of penicillin non-wild-type *Streptococcus pneumoniae*. Two (5%) of 43 countries reporting data on this microorganism had percentages below 5% in 2021,

whereas percentages equal to or above 25% were found in five (12%) countries (see Fig. 9 in Chapter 3).

Resistance to vancomycin in *Enterococcus faecium* varied substantially among countries in the Region. In 2021, resistance percentages of below 1% were reported by six (14%) of 44 countries reporting data on this microorganism, while percentages equal to or above 25% were found in 17 (39%), five of which (11% of 44 countries) reported resistance percentages equal to or above 50% (see Fig. 10 in Chapter 3).

Country-specific information for each bacterial species, including information on patient age group and sex, are available on the WHO European Region website [1].

Discussion

The results from CAESAR and EARS-Net clearly show that AMR is widespread in the WHO European Region. Although an assessment of the exact magnitude of AMR remains challenging, the presence of specific AMR patterns across clinical settings covered by the surveillance networks is apparent. High percentages of resistance to third-generation cephalosporins and carbapenems in *K. pneumoniae*, and high percentages of carbapenem-resistant *Acinetobacter* spp. in several countries, are of concern. They suggest the dissemination of resistant clones in healthcare settings and indicate that many countries have serious limitations in treatment options for patients with infections caused by these pathogens. While the west-to-east gradient in AMR percentages is evident for gram-negative bacteria (*E. coli*, *K. pneumoniae*, *P. aeruginosa*, *Acinetobacter* spp.), it is less obvious for gram-positive bacteria (*S. aureus*, *S. pneumoniae*, *E. faecium*). As bacterial microorganisms resistant to antimicrobials cannot be contained within borders or regions, these results underline the need for concerted action to combat AMR throughout the WHO European Region, and globally.

The impact of the COVID-19 pandemic on AMR is apparent. Many countries providing AMR data to CAESAR reported more *E. coli* isolates in 2021 than in 2020. This may be related to a steady increase in healthcare activities not directly linked to the COVID-19 response, possibly including more engagement in AMR surveillance activities. However, the higher number of *S. pneumoniae* isolates reported by many countries in the WHO European Region in 2021 than in 2020 may be due to the increasing circulation of respiratory pathogens in the community post-lockdown and the removal of enforced measures to control the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). On the other hand, typical healthcare-associated pathogens such as *Acinetobacter* spp. and *E. faecium* were more frequently observed in many countries during 2021 than in previous years.

Overall, more countries and laboratories reported data to the European surveillance networks in 2021 than in previous years, which is an encouraging step in the right direction. Nevertheless, when looking at surveillance capacity in the WHO European Region: 16% of countries still reported that they only collected AMR data at local level and did not have a standardised approach. This highlights the ongoing need to strive for enhanced standardisation as systems and networks continue to grow and mature.

Since the publication of the Global Action Plan on Antimicrobial Resistance (GAP-AMR) in 2015 [2], most Member States of the WHO European Region have enhanced efforts to tackle AMR. In 2017, only 34 (68%) of the 50 countries reported having developed a national action plan (NAP) on AMR, but the latest round of global monitoring showed that this had increased to 44 (85%) of the 52 countries that responded (see Table 6 in Chapter 3). The challenge ahead is to ensure comprehensive implementation and adequate funding for NAPs.

Similarly, efforts to improve antimicrobial consumption in the Region remain heterogeneous. During 2021, 19 of 28 (68%) EU/EEA countries reporting data for both the community and the hospital sector met or exceeded the WHO country-level target of 60% of total antibacterial consumption being derived from WHO's Access category (as defined in the Access, Watch, Reserve (AWaRe)[2] classification list) [3]. Only five of 18 countries reporting to the WHO Regional Office for Europe Antimicrobial Medicines Consumption Network achieved this target in 2019 [4].

Public health implications

AMR is one of the top 10 global public health threats facing humanity [5]. Although the number of countries in the Region that heeded the global call [2, 6] to develop NAPs on AMR has reached a high level, and many countries are already embarking on a revision of their NAPs for the next phase of implementation, there are some countries that have only just begun to implement effective interventions to tackle AMR. The same applies to AMR surveillance. Greater efforts and investment are required to increase the comparability, quantity and quality of AMR surveillance data. Current patterns, such as increases in carbapenem-resistant *Acinetobacter* spp. isolates that are difficult to eradicate once endemic, underline the need to enhance efforts to prevent and detect resistance. These patterns also highlight the role AMR surveillance can play in strengthening health system resilience and preparedness.

There is still a lack of high-level support and robust funding for comprehensive programmes and interventions on infection prevention and control (IPC), antimicrobial stewardship and surveillance and it is clear that commitment from the highest-level of government is crucial in order to advance the AMR agenda [7].

2 AWaRe classifies antibiotics into three stewardship groups – Access, Watch and Reserve – to emphasise the importance of their optimal uses and potential for AMR.

The COVID-19 pandemic has exposed the weaknesses in national health systems and the interconnectedness of countries and continents. The world is still adjusting to the effects of this pandemic on people and public health, and efforts to tackle AMR are only just beginning to find a balance after the reorganisation of healthcare professionals to support the COVID-19 response throughout the European Region. Across the globe, governments were confronted with a need for more coordinated action and collaboration and this has paved the way for a more united front against future health threats, including AMR. It is hoped that such a united front will enable us to respond more effectively to the looming threat represented by AMR in the coming years.

This report highlights the persistent disparities in AMR prevalence across the WHO European Region and details unexploited opportunities for counteracting AMR.

EU/EEA countries

As in the preceding years, all EU Member States and two EEA countries (Iceland and Norway) reported data for 2021 to EARS-Net [8]. Eighteen (62.1%) of these 29 countries reported that their participating laboratories had a population coverage of over two thirds of the national population, including 14 countries that reported having a national population coverage of 90.0% or more. However, seven countries reported data for less than half of their population (Table A3.2).

Twenty-two (75.9%) of the 29 participating countries indicated that their reported data had a high national representativeness, in terms of three metrics: the geographical areas covered, the acute care hospitals included, and the microorganisms that caused invasive infections in those hospitals. A further three countries reported that the representativeness was 'high' for two of the three metrics, and one country reported that the representativeness of its national data was 'low' for all three metrics (Table A3.2).

In hospitals served by the laboratories that reported data to EARS-Net in 2021, the blood culture rate was reported by 24 countries. In the 22 countries that reported a high national representativeness according to all three metrics listed above, the national average blood culture rate was 2.6 times higher than in the four countries reporting a medium or low national representativeness according to at least two of those metrics (76 versus 29 blood culture sets per 1000 patient-days, respectively). The reported blood culture rates were the highest in Belgium, Denmark, Finland, Portugal, and Spain (›100 sets per 1000 patient-days), and lowest in Bulgaria, Czechia, Hungary, Latvia, and Lithuania (‹25 sets per 1000 patient-days) (Table A3.2).

All but one country reported data for all eight bacterial species under surveillance by EARS-Net (*E. coli*, *K. pneumoniae*, *P. aeruginosa*, *Acinetobacter* spp., *S. pneumoniae*, *S. aureus*, *E. faecalis* and *E. faecium*), while one country (Greece) reported data for all bacterial species except *S. pneumoniae*.

The number of laboratories participating in EARS-Net continued to increase, indicating a strengthening of national AMR surveillance systems in the EU/EEA. In 2021, 1847 laboratories reported data, 1006 of which were in France. There were 666 laboratories identifiable as having reported data for each year during the period 2017–2021, as the reporting countries were able to provide a consistent laboratory identifier. These do not include ›85.0% of the laboratories in France and Greece that participated in 2021, either because there were major changes in the organisational structure of the national surveillance system (France), or because of the restriction of EARS-Net, starting with 2019 data, to only include laboratories using EUCAST methods and guidelines (Greece).

Epidemiology

The most commonly reported bacterial species in 2021 were *E. coli* (39.4%), followed by *S. aureus* (22.1%), *K. pneumoniae* (11.9%), *E. faecalis* (8.8%), *E. faecium* (6.2%), *P. aeruginosa* (6.1%), *Acinetobacter* spp. (3.0%) and *S. pneumoniae* (2.5%). This ranking was different to the ranking in 2020, with *E. faecium* and *Acinetobacter* spp. being ranked one place higher in 2021. Both 2020 and 2021 coincided with extreme pandemic-associated pressures on healthcare. Therefore, it is informative to also compare 2021 data with the years immediately before 2020. In addition, even though the national and EU/EEA representativeness of EARS-Net data is high, restricting analysis to laboratories known to have reported data continuously throughout 2017–2021 is a way of verifying trends. This 'restricted' dataset is very similar to the 'full' dataset. To illustrate this point, the overall number of isolates at EU/EEA level, for all bacterial species under surveillance, increased by 7.2% in 2021 compared to 2020 among laboratories that continuously reported data to EARS-Net during 2017–2021, and by 8.8% in all laboratories that reported during that period. Furthermore, among the 'restricted' set of laboratories that continuously reported data during 2017–2021 *S. pneumoniae* was reported more frequently than *Acinetobacter* spp. (3.2% and 2.8% of all reported bacterial species, respectively), but otherwise the ranking remained the same as in the full dataset. Within that same restricted group of laboratories, comparing 2021 to the average for 2018 and 2019, the largest increases in the number of reported isolates were for *Acinetobacter* spp. (+73.9%; 3523 and 6127, respectively) and *E. faecium* (+32.5%; 9926 and 13151, respectively) followed by *E. faecalis* (+11.7%; 15777 and 17620, respectively). There was almost no change in *K. pneumoniae* (+0.03%; 25044 and 25052, respectively) and *P. aeruginosa* (-0.9%; 12150 and 12035, respectively), and a decrease in the number of reported *S. aureus* isolates (-5.5%; 50267 and 47487, respectively), *E. coli* isolates (-11.8%; 99266 and 87526, respectively) and in particular *S. pneumoniae* isolates (-45.6%; 12629 and 6875, respectively) [9].

Acinetobacter spp. had by far the largest annual increase in the number of reported isolates in both 2020 and 2021. During 2017–2019, the number of isolates had been relatively stable (+/-10.0%). During 2017–2021, similar trends were observed for the number of reports of *Acinetobacter* spp. isolates that were resistant to each of the three antimicrobial groups presented in this report (i.e. carbapenems, fluoroquinolones and aminoglycosides) (Table 7b). Among the laboratories that continuously reported data during 2017–2021, the increase in the number of antimicrobial-resistant isolates was more pronounced in 2021 compared to the average for 2018 and 2019 (+121% on average, for each of these three groups). Furthermore, there was a large increase in the percentage of isolates resistant to carbapenems, reaching 48% in 2021 [9]. At country level in 2021, the percentage of resistant *Acinetobacter* spp. isolates among all reporting laboratories ranged from 0.0% to >98.0%, for each of the three antimicrobial groups individually and for combined resistance to all three groups (Table 7b).

The resistance profiles of both *Enterococcus* species under surveillance continue to be of concern. The percentage of *E. faecium* with vancomycin resistance continued to increase, reaching 17.2% in 2021. For *E. faecalis*, almost a third of all reported isolates had high level resistance to gentamicin in 2021.

Otherwise, overall for the EU/EEA and during the period 2017–2021, most of the bacterial species–antimicrobial combinations in this report showed either a significantly decreasing trend or no significant trend in the population-weighted mean AMR percentage. Exceptions included the trends described for *Acinetobacter* spp., and the EU/EEA population-weighted percentage of carbapenem resistance for both *E. coli* and *K. pneumoniae* which increased during the period 2017–2021 (Table 7b). Reports of carbapenem resistance remained relatively rare among *E. coli* isolates (0.2% in 2021). By contrast, in 2021, 11.7% *K. pneumoniae* isolates were carbapenem-resistant (country range: 0–80%). The EU/EEA population-weighted mean percentage of carbapenem resistance among *K. pneumoniae* isolates increased each year. The rate of increase relative to the previous year also increased each year during the period 2017–2021, by +5%, +6%, +11% and +17%, respectively. The annual relative change in the percentage of carbapenem-resistant *K. pneumoniae* isolates was even striking among the laboratories identified as continuously reporting data each year for 2017–2021 (+0%, +8%, +31% and +20% in 2018–2021, respectively) [9].

In general, the EU/EEA population-weighted AMR percentages were lower in *E. coli* than in *K. pneumoniae*, *P. aeruginosa* and *Acinetobacter* spp. Even so, 53.1% of all *E. coli* reported isolates in 2021 had resistance reported for at least one antimicrobial group under surveillance, compared to 43.0% of *Acinetobacter* spp., 34.3% of *K. pneumoniae* isolates and 18.7% of *P. aeruginosa* isolates. Among these four pathogens, combined resistance to several antimicrobial groups/agents remained a frequent occurrence, reported for 5.1% of *E. coli* isolates, 21.2% of *K. pneumoniae* isolates, 12.6% of *P. aeruginosa* isolates and 36.8% of *Acinetobacter* spp. isolates (Table 7b). For *S. aureus*, a significant decrease in the EU/EEA population-weighted percentage of MRSA isolates was reported during the period 2017–2021, from 18.4% to 15.8% (Table 7b). Nevertheless, MRSA is still an important pathogen in the EU/EEA, with percentages remaining high in several countries.

Country-specific information for each bacterial species, including results by patient age group and sex for specific AMR phenotypes, are available in the European Centre for Disease Prevention and Control (ECDC) Surveillance Atlas of Infectious Diseases [10]. The reported AMR percentages for several bacterial species–antimicrobial group combinations varied widely among EU/EEA countries, often with a north-to-south and west-to-east gradient. In general, the lowest AMR percentages were reported by countries in the north of Europe and the highest by countries in the south and east of Europe.

Discussion

In 2021, the AMR percentages for the bacterial species-antimicrobial group combinations under surveillance continued to be high overall in the EU/EEA. The increasing trends of carbapenem resistance percentages in *K. pneumoniae* and *Acinetobacter* spp. and of vancomycin-resistant *E. faecium* between 2017 and 2021 are of particular concern and indicate that AMR remains a serious challenge in the EU/EEA. As in previous years, there was a large variability in the percentages across EU/EEA countries in 2021, highlighting the opportunities for significant AMR reduction through interventions to improve infection prevention and control (IPC) and antimicrobial stewardship practices.

The data for the years 2020 and 2021 presented in this report coincide with the first years of the coronavirus disease (COVID-19) pandemic. Changes to human behaviour in 2020 and 2021, resulting from efforts to control the pandemic, modified the risk of infection by pathogens with AMR [11–12]. In the community, non-pharmaceutical interventions (NPIs) for COVID-19 to promote physical distancing reduced the number and duration of person-to-person contacts. During the first part of 2021, countries gradually reduced the intensity of NPI implementation, following vaccine-associated reductions in hospitalisations, intensive care unit (ICU) admissions and deaths due to COVID-19 [13–14]. In autumn and winter 2021, there was a resurgence in hospitalisations and ICU admissions for COVID-19 that led to national authorities reinforcing their public health messaging for COVID-19, with 'pandemic fatigue' frequently linked to reduced compliance with NPIs [15]. Large decreases in the total consumption of antibacterials for systemic use (ATC group J01) were noted during the first two years of the pandemic, in particular in the community. Changes were less consistent in the hospital sector, with increased consumption of last-line

antibiotics, particularly carbapenems [3]. In 2020–2021, there was delayed access to preventive, primary and elective healthcare, including surgery. More specialised care, for example for late diagnoses, commonly requires interventions that predispose patients to a higher risk of infection with an antimicrobial-resistant pathogen, such as the use of antimicrobial agents and invasive devices [16]. In addition, ICU admissions due to COVID-19 put a strain on ICU resources which necessitated the re-purposing of non-ICU beds and the allocation of non-ICU staff to meet the urgent demand. In healthcare, as in society, recommendations for conscientious IPC for respiratory viral pathogens were the norm. However, compliance with all IPC measures in healthcare is likely to have been adversely affected by high hospital patient loads, staff absenteeism due to COVID-19, and reliance on more junior staff [17–19]. In 2020 and 2021, even though national authorities in EU/EEA countries focussed public health resources on the response to COVID-19 in order to face the acute crisis, EU/EEA countries continued to strengthen their participation in EARS-Net. As a direct result, EARS-Net data can be used to confidently describe the ongoing AMR threat for the EU/EEA, because a majority of countries reported data that are nationally representative.

In 2022, ECDC used the national data reported to EARS-Net for 2016–2020 to estimate the burden of infections with antibiotic-resistant bacteria under surveillance in the EU/EEA [20]. The number of cases of these infections increased from 685 433 in 2016 to 865 767 in 2019, with a decrease in the estimate for 2020 to 801 517. These infections resulted in an estimated annual number of attributable deaths that increased from 30 730 deaths in 2016 to 38 710 deaths in 2019, before decreasing slightly to 35 813 deaths in 2020. During the period 2016–2020, the largest burden of disease was caused by infections with third-generation cephalosporin-resistant *E. coli*, followed by MRSA and third-generation cephalosporin-resistant *K. pneumoniae*. Infections with these three antibiotic-resistant bacteria resulted in the largest health impact, generating 58.2% of the total burden as measured in disability-adjusted life years (DALYs). ECDC estimated that for 2020, 30.9% of the total burden in DALYs was from infections with carbapenem-resistant bacteria. A similar number of deaths were attributable to carbapenem-resistant *K. pneumoniae*, (4 076 deaths), *Acinetobacter* spp. (3 656 deaths) and *P. aeruginosa* (3 210 deaths) [20].

The increase of most concern in the number of reported cases for the period 2020 to 2021 was for *Acinetobacter* spp. (in the EU/EEA, mostly *A. baumannii* complex), including isolates with carbapenem resistance. This increase was the largest of any pathogen under surveillance in EARS-Net for the second consecutive year. Countries with large increases in the number of *Acinetobacter* spp. cases in 2020–2021 had also reported a high percentage of antimicrobial-resistant *Acinetobacter* spp. in the years immediately prior to the COVID-19 pandemic. Conversely, countries that had not reported a high number of cases or AMR percentages prior to 2020 had the lowest numbers and percentages in 2021. In the countries with increases in the number of reported cases in 2020–2021, most of the newly reported cases were among ICU patients, with the majority of isolates resistant to carbapenems, a common group of antibiotics for empiric treatment of healthcare-associated infections [21]. During the period 2020–2022, *Acinetobacter* spp. was often reported as the most frequent bacterial coinfection for COVID-19 patients in hospitals, and particularly ICUs, in Europe, North America and the Middle East, causing clonal outbreaks, with high case fatality rates often associated with multidrug resistance [22–25]. The reasons for the increased number of *Acinetobacter* spp. infections in many EU/EEA countries warrant further investigation, although they are probably directly related to pandemic-related changes in healthcare provision. *Acinetobacter* spp., and multidrug-resistant strains in particular, are notoriously difficult to eradicate from the hospital environment once established, surviving on dry surfaces, readily contaminating healthcare providers' hands, and being spread by asymptomatic carriers [22]. Given the unprecedented patient loads in ICUs across the EU/EEA in 2020–2021, even hospitals that rigorously and conscientiously applied IPC practices may still have had opportunities for IPC breaches sufficient for *Acinetobacter* spp. transmission [11]. This suggests a requirement for *Acinetobacter* spp.-specific control interventions in the affected hospitals [26]. EARS-Net will continue to report annual *Acinetobacter* spp. data in the 'post-pandemic' years to come, to facilitate assessment of trends in this relatively persistent hospital contaminant.

Trends in *P. aeruginosa* cases might have been expected to follow those observed for *Acinetobacter* spp., given the rate of ventilator use among hospitalised COVID-19 cases and the fact that *P. aeruginosa* is also often linked to environmental sources. However, the trends for *P. aeruginosa* remained relatively unchanged. Pandemic-related factors may partially explain this - for example, changes in the lengths of hospital stays, and greater shielding of patients at risk of both COVID-19 and *P. aeruginosa* infection, such as cystic fibrosis patients. Nevertheless, ECDC does not have incidence surveillance for pneumonias and lower respiratory tract infections, which, for *P. aeruginosa*, are the site of three times as many healthcare-associated infections [27].

For *S. pneumoniae*, the decrease in the number of cases observed in 2020 continued in 2021, overall and for isolates resistant to the antimicrobials under surveillance. This may be related to reduced risk factors for such infections during the waves of the COVID-19 pandemic (such as a decrease in the frequency of inter-personal contacts, influenza incidence, and antibiotic prescriptions, and perhaps a lower incidence of blood cultures for community-acquired infections) [3, 28].

The monitoring framework for the United Nations Sustainable Development Goals includes two AMR indicators. These monitor the percentage of bloodstream

infections due to meticillin-resistant *S. aureus* (MRSA) and *E. coli* resistant to third-generation cephalosporins among patients seeking care whose blood samples have been tested [29]. Among the laboratories in EU/EEA countries that continuously reported data during the period 2017–2021, the resistance percentages decreased for both pathogens [9]. Among the laboratories that continuously reported data each year during the period 2017–2021, the decrease in the annual number of MRSA isolates reported for 2019–2020 has reversed somewhat in 2020–2021. However, the decreasing trend in the percentage of third-generation cephalosporin-resistant *E. coli* was maintained [9]. These EU/EEA trends in the EU/EEA (excluding the United Kingdom) population-weighted mean percentage were also seen in the overall data. It is worth noting that the AMR percentages varied widely among countries, suggesting that there are further opportunities for reduction. In particular, before 2020, the annual reductions in the percentage of *S. aureus* resistant to meticillin were explained by the relatively large and ongoing increase in the number of reported meticillin-susceptible *S. aureus* (MSSA) infections, while the annual number of reported MRSA infections remained relatively stable [30].

When interpreting the EARS-Net data, it is important to be mindful of the structure of this surveillance system, including the large variation in national blood culture rates, and the changes in surveillance systems over time. Although the restriction of EARS-Net from 2019 onwards, to only accept data generated using EUCAST breakpoints and methodology, should improve the quality and comparability of data in the long term, it resulted in fewer laboratories participating in a number of countries in 2019. Moreover, there has not been any systematic assessment of the characteristics and AMR percentages of the EU/EEA laboratories that do not report to EARS-Net. Indeed, seven of 29 countries reported data with less than 50.0% population coverage. Similarly, the laboratories that were identifiable as having reported data for five consecutive years may also be atypical compared to other laboratories in the same country. Finally, as noted above, trends in AMR percentages are also affected by changes to country surveillance systems, and by changes to EARS-Net itself. For example, the lower percentages of aminoglycoside resistance reported for *P. aeruginosa* in both 2020 and 2021 reflect an update of the EARS-Net reporting protocol for 2020 data. Therefore, the analysis of data from 2020 onwards only includes tobramycin susceptibility test results, whereas previous years include tobramycin, netilmicin and gentamicin. Irrespective of these limitations, EU/EEA-level analyses from EARS-Net surveillance data are probably an accurate reflection of the overall AMR situation in the EU/EEA.

The COVID-19 pandemic has led to several developments that will help the EU address infectious disease threats, including AMR, as well as boosting action on health and health security under the European Health Union [31]. The European Health Union includes strengthened mandates for ECDC and the European Medicines Agency (EMA), the creation of the European Health Emergency preparedness and Response Authority (HERA) and a new Regulation on serious cross-border threats to health. A much larger budget is available under the EU4Health programme (EUR 5.3 billion for the period 2021–2027), which is one of the main instruments for the European Health Union, dedicated to wider policy areas and including action on AMR.

The new Regulation on serious cross-border threats to health, adopted by the Council on 24 October 2022 [32], provides a revised regulatory framework for preparedness, surveillance, risk assessment, early warning and responses at EU and Member State level in the event of biological, chemical, environmental or other cross-border threats to health, repealing the previous Decision (EU 1082/2013) [33]. The new elements include the development of a European Union preparedness plan, a system to regularly assess national plans, and a strengthening of Member State interactions in the Health Security Committee. The Regulation also provides for the establishment of EU reference laboratories, coordinated by ECDC, to support national reference laboratories in the Member States, in coordination with the World Health Organization (WHO) Reference Laboratories. The EU reference laboratories will support comparable disease notification and Member State reporting by promoting good practice and voluntary alignment of diagnostic methodologies. To achieve this, the reference laboratories network activities may be expanded to cover reference diagnostics, including support for outbreak responses, provision of reference materials, external quality assessments and training, scientific advice, collaboration and research.

Public health implications

Public health action to tackle AMR in the EU/EEA remains insufficient, despite the increased awareness of AMR as a threat to public health and the availability of evidence-based guidance for IPC, antimicrobial stewardship and adequate microbiological capacity. AMR will be an increasing concern unless governments respond more robustly to the threat. Estimates based on data from EARS-Net show that in 2020, more than 800 000 infections occurred in the EU/EEA due to bacteria resistant to antibiotics, and that more than 35 000 people died as a direct consequence of these infections [20].

During the first two years of the COVID-19 pandemic (2020–2021), the most striking increase in the number of cases, compared to the period before 2020, was for carbapenem-resistant *Acinetobacter* spp. infections, mostly in countries that had a relatively high percentage of carbapenem-resistant cases pre-pandemic. *Acinetobacter* spp., including carbapenem-resistant isolates, cause outbreaks and are difficult to eradicate once they become endemic. It is therefore likely that carbapenem-resistant *Acinetobacter* spp. will continue to expand in the EU/EEA in 2022. The options for outbreak preparedness, prevention and control described in the ECDC Rapid Risk Assessment 'Carbapenem-resistant

Acinetobacter baumannii in healthcare settings – 8 December 2016', remain valid for hospitals and national authorities in EU/EEA countries [26, 34].

Further investment in public health interventions is urgently needed to tackle AMR. This would have a significant positive impact on population health and future healthcare expenditure in the EU/EEA. It has been estimated that a mixed intervention package including enhanced hygiene, antibiotic stewardship programmes, mass media campaigns, and the use of rapid diagnostic tests would have the potential to prevent approximately 27 000 deaths each year in the EU/EEA. In addition to saving lives, such a package could pay for itself within just one year and save around EUR 1.4 billion per year in the EU/EEA [35].

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Краткий обзор

Европейский регион ВОЗ

Результаты, представленные в этом докладе, основаны на данных об устойчивости инвазивных изолятов к противомикробным препаратам (УПП), сообщенных в CAESAR (Сеть эпиднадзора за устойчивостью к противомикробным препаратам в Центральной Азии и Европе) и в EARS-Net (Европейская сеть эпиднадзора за устойчивостью к противомикробным препаратам) в 2022 г. (данные относятся к 2021 г.). В целом 16 стран предоставили данные в CAESAR и 29 стран, включая все страны Европейского союза (ЕС) и две страны, входящие в Европейскую экономическую зону (ЕЭЗ) (Исландия и Норвегия), сообщили данные в EARS-Net. Хотя сети CAESAR и EARS-Net используют сопоставимые методы сбора и анализа данных, результаты, представленные в докладе, получены отличающимися национальными системами эпиднадзора. На эти результаты неизбежно влияют конкретные протоколы и практики, поэтому рекомендуется проявлять осторожность при сравнении профилей УПП между странами.

Эпидемиология

Согласно сообщениям, предоставленным в сети эпиднадзора за УПП в 2021 г., ситуация с устойчивостью у разных видов бактерий широко варьировалась в зависимости от вида бактерий, группы противомикробных препаратов и географического региона (см. рис. 1–10, глава 3). Устойчивость к цефалоспоринам 3-го поколения и карбапенемам обычно была выше у *Klebsiella pneumoniae*, чем у *Escherichia coli*. В большинстве стран устойчивость *E. coli* к карбапенемам по-прежнему была редкостью, но при этом 33% стран сообщили о доле устойчивости *K. pneumoniae* к этой группе антибиотиков, составившей 25% или выше. Устойчивость к карбапенемам также была обычным явлением у *Pseudomonas aeruginosa* и *Acinetobacter* spp., причем процентные доли устойчивых штаммов были выше, чем у *K. pneumoniae*. Как отмечалось в предыдущих региональных докладах, наблюдается градиент устойчивости, направленный с севера на юг и с запада на восток; при этом более высокие показатели наблюдаются в южной и восточной частях Региона по сравнению с северными и западными. Это было особенно характерно для устойчивости *K. pneumoniae* к цефалоспоринам 3-го поколения и карбапенемам и устойчивости *Acinetobacter* spp. к карбапенемам.

При рассмотрении результатов только 13 стран, приславших в CAESAR данные как в 2020 г., так и в 2021 г., обнаружено, что общее число изолятов было выше в 2021 г., чем в 2020 г. Это стало результатом повышения общего числа изолятов всех исследованных патогенов. На страновом уровне подобные общие тенденции наблюдались не всегда; однако все страны сообщили о получении в 2021 г. большего числа изолятов *Acinetobacter* spp., чем в 2020 г. Во всех 16 странах, сообщивших данные в CAESAR в 2021 г., основная часть выделенных изолятов (70%) относилась к *E. coli* (37,9%), *Staphylococcus aureus* (17,2%) и *K. pneumoniae* (14,9%).

Рассматривая результаты по отдельным видам бактерий в 2021 г., можно сказать, что устойчивость *E. coli* к фторхинолонам в целом была самой низкой в северных частях Европейского региона ВОЗ и самой высокой на юге (см. рис. 1, глава 3). Процент устойчивости ниже 10% наблюдался в 2 (4%) из 45 стран, сообщивших данные об этом микроорганизме. Доля устойчивости 25% или выше зарегистрирована в 17 (38%) странах, а доля устойчивости 50% или выше – в 4 (9%) странах. Что касается устойчивости *E. coli* к цефалоспоринам 3-го поколения, 12 (27%) из 45 стран сообщили о показателях ниже 10%, тогда как доля устойчивости, равная или превышающая 50%, выявлена в 4 (9%) странах. Из 44 стран 8 (18%) сообщили, что доля *E. coli*, устойчивых к карбапенемам, составляла 1% или выше (см. рис. 3, глава 3).

Устойчивость *K. pneumoniae* к цефалоспоринам 3-го поколения широко распространилась в Европейском регионе ВОЗ. В 2021 г. доля устойчивости ниже 10% наблюдалась в 7 (16%) из 45 стран, сообщивших данные об этом микроорганизме, а 19 (42%) стран, особенно в южной и восточной частях Региона, сообщили о процентной доле устойчивости 50% или выше (см. рис. 4, глава 3). Устойчивость к карбапенемам чаще отмечалась у *K. pneumoniae*, чем у *E. coli*. В 2021 г. доля устойчивости в целом была низкой в северной и западной частях Европейского региона ВОЗ; 14 (31%) из 45 стран сообщили о доле устойчивости ниже 1% (см. рис. 5, глава 3); 15 (33%) стран сообщили о процентных долях, равных или превышающих 25%; 8 из них (18% из 45 стран) сообщили о долях устойчивости, равных или превышающих 50%.

В Европейском регионе наблюдались большие различия в процентных долях устойчивых к карбапенемам *P. aeruginosa*. В 2021 г. доля устойчивости менее 5% выявлена в 2 (5%) из 44 стран, представивших данные об этом микроорганизме, тогда как 6 (14%) стран сообщили о долях, равных или превышающих 50% (см. рис. 6, глава 3).

В 2021 г. в Регионе наблюдались значительные различия в процентных долях устойчивых к карбапенемам штаммов *Acinetobacter* spp.: от менее 1% в 3 (7%) из 45 стран, сообщивших данные об этом

микроорганизме, до 50% или выше в 25 (56%) странах, расположенных преимущественно в южной и восточной частях Европы (см. рис. 7, глава 3).

В 2021 г. в 11 (25%) из 44 стран, сообщивших данные о *S. aureus*, процентные доли штаммов *S. aureus*, устойчивых к метициллину (MRSA), были ниже 5% (см. рис. 8, глава 3). В 13 (30%) странах из 44 выявленные процентные доли MRSA были равны или выше 25%.

Значительные различия наблюдались в Регионе в процентных долях устойчивых к пенициллину *Streptococcus pneumoniae* недикого типа. В 2 (5%) из 43 стран, сообщивших данные об этом микроорганизме, в 2021 г. процентные доли устойчивости составляли менее 5%, тогда как в 5 (12%) странах эти показатели были равны или превышали 25% (см. рис. 9, глава 3).

Устойчивость *Enterococcus faecium* к ванкомицину в различных странах Региона отличалась существенно. В 2021 г. о долях устойчивости менее 1% сообщили 6 (14%) из 44 стран, предоставивших данные об этом микроорганизме, в то время как процентные доли 25% или выше обнаружены в 17 (39%) странах, 5 из которых (11% из 44 стран) сообщили о процентных долях устойчивости, составлявших 50% или выше (см. рис. 10, глава 3).

Информация о каждой конкретной стране для конкретного вида бактерий, включая данные о возрастной группе и половой принадлежности пациента, доступна на веб-сайте Европейского региона ВОЗ [1].

Обсуждение

Результаты CAESAR и EARS-Net ясно показывают, что УПП широко распространена в Европейском регионе ВОЗ. Хотя точная оценка масштаба проблемы УПП остается сложной задачей, наличие определенных профилей УПП в клинических учреждениях, охваченных сетями эпиднадзора, очевидно. Вызывают озабоченность наблюдаемые в некоторых странах высокие процентные доли устойчивости к цефалоспоринам 3-го поколения и карбапенемам у *K. pneumoniae*, а также значительные доли устойчивых к карбапенемам *Acinetobacter* spp. в некоторых странах. Это может свидетельствовать о распространении устойчивых клонов в медицинских учреждениях, а также указывать на серьезные ограничения вариантов лечения пациентов с инфекциями, вызванными этими патогенами, во многих странах. В то время как градиент процентных долей УПП с запада на восток очевиден для грамотрицательных бактерий (*E. coli*, *K. pneumoniae*, *P. aeruginosa*, *Acinetobacter* spp.), он менее выражен в отношении грамположительных бактерий (*S. aureus*, *S. pneumoniae*, *E. faecium*). Поскольку распространение устойчивых к противомикробным препаратам бактерий невозможно сдерживать в пределах границ или регионов, полученные результаты подчеркивают необходимость согласованных действий по борьбе с УПП как во всем Европейском регионе ВОЗ, так и в мировом масштабе.

Влияние пандемии COVID-19 на УПП очевидно. Многие страны, предоставляющие данные об УПП в CAESAR, сообщили, что получено больше изолятов *E. coli* в 2021 г., чем в 2020 г. Это может быть связано с неуклонным расширением деятельности органов здравоохранения в областях, непосредственно не связанных с реагированием на COVID-19, возможно, включая более активное участие в мероприятиях по эпиднадзору за УПП. Многие страны Европейского региона ВОЗ сообщили о выделении большего количества изолятов *S. pneumoniae* в 2021 г., чем в 2020 г. Вероятно, это связано с усилением циркуляции респираторных патогенов среди населения после отмены изоляции и принудительных мер борьбы с распространением SARS-CoV-2 (коронавирус тяжелого острого респираторного синдрома-2). С другой стороны, во многих странах в 2021 г. чаще, чем в предыдущие годы, выделяли такие типичные возбудители инфекций, связанные с оказанием медицинской помощи, как *Acinetobacter* spp. и *E. faecium*.

В целом в 2021 г. больше стран и лабораторий сообщили данные в Европейские сети эпиднадзора, чем в предыдущие годы, что является обнадеживающим шагом в правильном направлении. Тем не менее при рассмотрении возможностей эпиднадзора в Европейском регионе ВОЗ следует отметить, что 16% стран по-прежнему сообщают, что они собирают данные об УПП только на местном уровне и не используют стандартизированный подход. Это подчеркивает постоянную необходимость стремиться к усилению стандартизации по мере того, как системы и сети продолжают расти и развиваться.

С момента публикации в 2015 г. Глобального плана действий по борьбе с устойчивостью к противомикробным препаратам (ГПД-УПП) [2] большинство государств-членов Европейского региона ВОЗ активизировали усилия по противодействию УПП. В 2017 г. только 34 (68%) из 50 стран сообщили о разработке национального плана действий (НПД) по УПП, тогда как последний раунд глобального мониторинга показал, что это число увеличилось до 44 (85%) из 52 стран-респондентов Региона (см. табл. 6, глава 3). Предстоящая задача состоит в том, чтобы обеспечить всеобъемлющее осуществление и адекватное финансирование НПД.

Точно так же попытки оптимизировать потребление противомикробных препаратов в Регионе остаются неравнозначными. В течение 2021 г. 19 из 28 (68%) стран ЕС/ЕЭЗ, предоставивших данные, относящиеся как к местному населению, так и к больничному сектору, достигли или превысили на страновом уровне целевой показатель ВОЗ, согласно которому 60% общего потребления антибиотиков должно приходиться на категорию «доступ» [как определено в классификационном списке «Доступ, наблюдение, резерв» (AWaRe)] [3]. Только 5 из 18 стран, отчитавшихся перед Сетью Европейского регионального

бюро ВОЗ по потреблению противомикробных препаратов, достигли этой цели в 2019 г. [4].

Последствия для общественного здравоохранения

УПП – одна из 10 главных угроз общественному здравоохранению, с которыми сталкивается человечество [5]. Хотя число стран в Регионе, откликнувшихся на глобальный призыв [2, 6] разработать НПД по УПП, достигло высокого уровня и многие страны уже приступают к пересмотру своих НПД для следующего этапа реализации, некоторые из стран только начали осуществлять эффективные меры по борьбе с УПП. То же самое относится и к эпиднадзору за УПП. Необходимы дополнительные усилия и инвестиции для повышения сопоставимости, количества и качества данных эпиднадзора за УПП. Такие наблюдающиеся сегодня явления, как увеличение числа изолятов *Acinetobacter* spp., устойчивых к карбапенемам и с трудом поддающихся, искоренению после того, как они становятся эндемичными, подчеркивают необходимость активизации усилий по предотвращению и выявлению устойчивости. Обнаруженные особенности также показывают, какую роль может играть эпиднадзор за УПП в укреплении устойчивости функционирования и готовности систем здравоохранения к чрезвычайным ситуациям.

По-прежнему недостаточны поддержка на высоком уровне и надежное финансирование комплексных программ и мероприятий по профилактике инфекций и инфекционному контролю (ПИИК), рациональному использованию противомикробных препаратов и эпиднадзору. Не вызывает сомнения, что приверженность на самом высоком правительственном уровне имеет решающее значение для продвижения вперед в соответствии с повесткой дня по борьбе с УПП [7].

Пандемия COVID-19 выявила слабые места в национальных системах здравоохранения и взаимозависимость стран и континентов. Мир еще только приспосабливается к последствиям этой пандемии как для людей, так и для общественного здравоохранения. Во всем Европейском регионе усилия, направленные на борьбу с УПП, только начинают приобретать сбалансированный характер после перепрофилирования медицинских работников для поддержки мер реагирования на пандемию COVID-19. По всему миру правительства столкнулись с необходимостью более скоординированных действий и сотрудничества, и это проложило путь для создания единого фронта против будущих угроз здравоохранению, включая УПП. Есть надежда, что такой единый фронт позволит нам в ближайшие годы более эффективно реагировать на надвигающуюся угрозу, которую представляет собой УПП.

В этом докладе подчеркивается, что по-прежнему сохраняются различия в распространенности УПП в Европейском регионе ВОЗ; также в нем раскрываются неиспользованные возможности противодействия УПП.

Страны ЕС/ЕЭЗ

Как и в предыдущие годы, все государства-члены ЕС и две страны ЕЭЗ (Исландия и Норвегия) предоставили данные за 2021 г. в EARS-Net [8]. Восемнадцать (62,1%) из этих 29 стран сообщили, что охват услугами, предоставленными лабораториями-участниками, составил свыше двух третей населения их стран, в том числе 14 стран сообщили об охвате 90,0% населения и более. В то же время данные, сообщенные 7 странами, охватывали менее чем половину населения (табл. A3.2).

Двадцать две (75,9%) из 29 стран-участниц продемонстрировали, что предоставленные ими данные имеют высокую национальную репрезентативность по трем показателям: охват географических районов, включение в эпиднадзор больниц скорой помощи и определение в этих больницах микроорганизмов, вызывающих инвазивные инфекции. Еще 3 страны сообщили, что репрезентативность была «высокой» для двух из трех показателей, а одна страна сообщила, что репрезентативность ее национальных данных по всем трем показателям была «низкой» (табл. A3.2).

О частоте исследования гемокультур в больницах, обслуживаемых лабораториями, предоставившими данные в EARS-Net в 2021 г., сообщили 24 страны. В 22 странах, сообщивших о высокой национальной репрезентативности по всем трем вышеперечисленным показателям, средний показатель исследования гемокультур по стране был в 2,6 раза выше, чем в 4 странах, сообщивших о среднем или низком уровне национальной репрезентативности по крайней мере по двум из этих показателей (76 наборов для исследования гемокультур на 1000 пациенто-дней по сравнению с 29 наборами соответственно). Зарегистрированные показатели посевов крови были самыми высокими в Бельгии, Дании, Испании, Португалии и Финляндии (>100 наборов на 1000 пациенто-дней) и самыми низкими в Болгарии, Венгрии, Латвии, Литве и Чехии (<25 наборов на 1000 пациенто-дней) (табл. A3.2).

Все страны, кроме одной, сообщили данные по всем 8 бактериальным видам, подлежащим эпиднадзору в EARS-Net (*E. coli*, *K. pneumoniae*, *P. aeruginosa*, *Acinetobacter* spp., *S. pneumoniae*, *S. aureus*, *E. faecalis* и *E. faecium*), в то время как одна страна (Греция) сообщила данные по всем бактериальным видам, кроме *S. pneumoniae*.

Количество лабораторий, участвующих в EARS-Net, продолжало расти, что является свидетельством укрепления национальных систем эпиднадзора за УПП в ЕС/ЕЭЗ. В 2021 г. данные представили 1847 лабораторий, 1006 из которых находились во Франции. Выявлено, что в период 2017–2021 гг. 666 лабораторий сообщали данные ежегодно. Это подтверждалось тем, что страны, представившие отчетность, смогли предоставить последовательные лабораторные идентификаторы. Сюда не входят >85,0% лабораторий Франции и Греции, участвовавших в эпиднадзоре в

2021 г. Это обусловлено либо серьезными изменениями в организационной структуре национальной системы эпиднадзора (Франция), либо ограничением EARS-Net, согласно которому, начиная с 2019 г., можно регистрировать только данные лабораторий, использующих методы и рекомендации EUCAST (Греция).

Эпидемиология

В 2021 г. чаще всего регистрировали *E. coli* (39,4%), затем следовали *S. aureus* (22,1%), *K. pneumoniae* (11,9%), *E. faecalis* (8,8%), *E. faecium* (6,2%), *P. aeruginosa* (6,1%), *Acinetobacter* spp. (3,0%) и *S. pneumoniae* (2,5%). Этот порядок отличался от порядка 2020 г.: *E. faecium* и *Acinetobacter* spp. в 2021 г. переместились на одно место выше. В 2020 и 2021 гг. получение данных совпало с чрезвычайной нагрузкой на здравоохранение из-за пандемии. В связи с этим полезно также сравнить данные за 2021 г. с данными за годы, непосредственно предшествовавшие 2020 г. Кроме того, несмотря на высокую репрезентативность данных EARS-Net по отдельным странам и в целом по ЕС/ЕЭЗ, анализ, ограниченный лабораториями, о которых известно, что они непрерывно сообщали данные в течение 2017–2021 гг., позволяет проверить указанные тенденции. Этот «ограниченный» набор данных имеет выраженное сходство с «полным» набором данных. Иллюстрацией является увеличение в 2021 г. по сравнению с 2020 г. общего количества всех подлежащих эпиднадзору видов бактерий в ЕС/ЕЭЗ на 7,2% среди лабораторий, которые постоянно сообщали данные в EARS-Net в течение 2017–2021 гг., и на 8,8% во всех лабораториях, сообщавших данные в этот период. Кроме того, среди «ограниченного» набора данных (лаборатории, ежегодно сообщавшие данные в течение 2017–2021 гг.) изоляты *S. pneumoniae* регистрировали чаще, чем *Acinetobacter* spp. (3,2% и 2,8% всех зарегистрированных видов бактерий соответственно). В остальном ранжирование осталось таким же, как и в «полном» наборе данных. В той же ограниченной группе лабораторий сравнение данных 2021 г. со средними показателями за 2018 и 2019 гг. показывает наибольшее увеличение количества зарегистрированных изолятов *Acinetobacter* spp. (+73,9%; 3523 и 6127 соответственно) и *E. faecium* (+32,5%; 9926 и 13151 соответственно), за которыми следовали *E. faecalis* (+11,7%; 15777 и 17620 соответственно). Почти не было изменений в количестве изолятов *K. pneumoniae* (+0,03%; 25044 и 25052 соответственно) и *P. aeruginosa* (-0,9%; 12150 и 12035 соответственно). Количество зарегистрированных изолятов *S. aureus* (-5,5%; 50267 и 47487 соответственно), изолятов *E. coli* (-11,8%; 99266 и 87526 соответственно) и особенно изолятов *S. pneumoniae* (-45,6%; 12629 и 6875 соответственно) уменьшилось [9].

Как в 2020, так и в 2021 г., наблюдалось наибольшее годовое увеличение количества зарегистрированных изолятов *Acinetobacter* spp., а в период 2017–2019 гг. количество этих изолятов было относительно стабильным (±10,0%). В 2017–2019 гг. наблюдались сходные тенденции в отношении зарегистрированных изолятов *Acinetobacter* spp., устойчивых к каждой из 3 групп противомикробных препаратов, представленных в этом докладе (то есть к карбапенемам, фторхинолонам и аминогликозидам) (табл. 7b). Среди лабораторий, которые постоянно сообщали данные в период 2017–2021 гг., увеличение количества устойчивых к противомикробным препаратам изолятов было более выражено в 2021 г. по сравнению со средними показателями 2018 и 2019 гг. (+121% в среднем для каждой из этих 3 групп). Кроме того, наблюдался значительный рост процентной доли изолятов, устойчивых к карбапенемам, достигавший в 2021 г. 48% [9]. На уровне стран в 2021 г. процентная доля устойчивых изолятов *Acinetobacter* spp.(по сообщениям всех предоставлявших данные лабораторий) колебалась от 0,0% до >98,0% для каждой из 3 групп антибиотиков и для комбинированной устойчивости ко всем трем группам (табл. 7b).

Профили устойчивости обоих видов Enterococcus, подлежащих эпиднадзору, все еще вызывают озабоченность. Процентная доля *E. faecium*, устойчивых к ванкомицину, продолжала расти, достигнув 17,2% в 2021 г. Что касается *E. faecalis*, то в 2021 г. почти у трети всех зарегистрированных изолятов выявлен высокий уровень устойчивости к гентамицину.

С другой стороны, в целом по ЕС/ЕЭЗ и за период 2017–2021 гг. большинство комбинаций вид бактерий–противомикробный препарат, представленных в этом докладе, показали либо тенденцию к значительному снижению средневзвешенной по численности населения процентной доли УПП, либо отсутствие значимой тенденции. К исключениям относились тенденции, описанные для *Acinetobacter* spp., и взвешенная по численности населения ЕС/ЕЭЗ процентная доля устойчивости к карбапенемам как для *E. coli*, так и для *K. pneumoniae*, которая увеличилась в период 2017–2021 гг. (табл. 7b). Сообщения об устойчивости к карбапенемам среди изолятов *E. coli* оставались относительно редкими (0,2% в 2021 г.). Напротив, в 2021 г. 11,7% изолятов *K. pneumoniae* были устойчивы к карбапенемам (диапазон в странах: 0–80%). Средневзвешенный по численности населения ЕС/ЕЭЗ процент устойчивости к карбапенемам среди изолятов *K. pneumoniae* увеличивался с каждым годом. Темпы роста по сравнению с предыдущим годом также ежегодно росли в период 2017–2021 гг. на +5%, +6%, +11% и +17% соответственно. Годовое относительное изменение процентной доли устойчивых к карбапенемам изолятов *K. pneumoniae* даже можно было назвать поразительным для лабораторий, которые сообщали данные ежегодно в 2017–2021 гг. (+0%, +8%, +31% и +20% в 2018–2021 гг. соответственно) [9].

В целом процентное соотношение УПП, взвешенное по численности населения ЕС/ЕЭЗ, было ниже для *E. coli*, чем для *K. pneumoniae*, *P. aeruginosa*

и *Acinetobacter* spp. Тем не менее 53,1% всех изолятов *E. coli*, зарегистрированных в 2021 г., обладали устойчивостью по крайней мере к одной группе противомикробных препаратов, охваченных эпиднадзором, по сравнению с 43,0% изолятов *Acinetobacter* spp., 34,3% – *K. pneumoniae* и 18,7% – *P. aeruginosa*. Среди этих 4 патогенов комбинированная устойчивость к нескольким группам противомикробных препаратов/агентам оставалась частым явлением: 5,1% изолятов *E. coli*, 21,2% – *K. pneumoniae*, 12,6% – *P. aeruginosa* и 36,8% – *Acinetobacter* spp. (табл. 7b). Что касается *S. aureus*, то в период 2017–2021 гг. было зарегистрировано значительное снижение взвешенной по численности населения ЕС/ЕЭЗ процентной доли изолятов MRSA с 18,4% до 15,8% (табл. 7b). Тем не менее MRSA по-прежнему является важным патогеном в ЕС/ЕЭЗ, и в некоторых странах его процентная доля остается высокой.

Информация относительно конкретных фенотипов УПП в каждой стране и для каждого вида бактерий, включая результаты по возрастным группам и полу пациентов, доступна в Атласе эпиднадзора за инфекционными заболеваниями Европейского центра профилактики и контроля заболеваний (ECDC) [10]. Зарегистрированные процентные доли УПП для нескольких комбинаций вид бактерий–группа противомикробных препаратов значительно различались в странах ЕС/ЕЭЗ, часто с градиентом с севера на юг и с запада на восток. В целом самые низкие показатели УПП были зарегистрированы в странах севера Европы, а самые высокие – в странах юга и востока Европы.

Обсуждение

В 2021 г. процентные доли УПП для комбинаций вид бактерий–группа противомикробных препаратов, подлежащих эпиднадзору, в целом для ЕС/ЕЭЗ оставались высокими. Тенденции к росту в отношении устойчивости к карбапенемам у *K. pneumoniae* и *Acinetobacter* spp. и к ванкомицину у *E. faecium* в период 2017–2021 гг. вызывают особую озабоченность и указывают на то, что УПП остается в ЕС/ЕЭЗ серьезной проблемой. Как и в предыдущие годы, в странах ЕС/ЕЭЗ в 2021 г. наблюдались существенные различия в процентных долях УПП. Это указывает на возможности значительного снижения УПП за счет мер по улучшению профилактики инфекций и инфекционного контроля (ПИИК) и вмешательств по рациональному использованию противомикробных препаратов.

Получение данных за 2020 и 2021 гг., представленных в этом докладе, совпало с первыми годами пандемии коронавирусной инфекции (COVID-19). В течение 2020 и 2021 гг. перемены в поведении людей, вызванные действиями по борьбе с COVID-19, видоизменили риск заражения устойчивыми патогенами [11–12]. Среди населения немедикаментозные вмешательства (НМВ) в отношении COVID-19, направленные на поощрение физического дистанцирования, сократили количество и продолжительность контактов между людьми. В течение первой половины 2021 г. страны постепенно снижали интенсивность внедрения НМВ после связанного с вакцинацией сокращения госпитализаций, поступлений в отделения реанимации и интенсивной терапии (ОРИТ) и смертности от COVID-19 [13–14]. Осенью и зимой 2021 г. наблюдался всплеск госпитализаций и поступлений в ОРИТ по поводу COVID-19, что привело к тому, что национальные органы снова усилили распространение информации относительно COVID-19 по каналам общественного здравоохранения; при этом «усталость от пандемии» часто была связана со снижением соблюдения НМВ [15]. В течение первых 2 лет пандемии отмечено значительное снижение общего уровня потребления антибактериальных препаратов для системного применения (группа J01 АТС), особенно среди населения. Изменения были менее выраженными в больничном секторе, где увеличилось потребление антибиотиков последней линии, особенно карбапенемов [3]. В 2020–2021 гг. доступ к профилактической, первичной и плановой медицинской помощи, включая хирургию, был отсрочен. Более специализированная помощь (например, при позднем диагнозе) обычно требует вмешательств (например, использование противомикробных агентов и инвазивных устройств), при которых у пациентов может возрастать риск заражения устойчивыми к противомикробным препаратам патогенами [16]. Кроме того, госпитализация в ОРИТ из-за COVID-19 увеличила нагрузку на ресурсы этих отделений. Для удовлетворения неотложных потребностей потребовалось перепрофилирование коек и привлечение персонала, обычно не занятого в ОРИТ. Для защиты от респираторных вирусных патогенов имелись полноценные рекомендации по ПИИК как для медицинских учреждений, так и для населения. Однако на соблюдение в здравоохранении всех мер ПИИК, вероятно, негативно повлияла высокая загруженность больниц, невыходы сотрудников на работу из-за COVID-19 и опора на более молодой персонал [17–19]. Даже несмотря на то, что в 2020 и 2021 гг. органы власти стран ЕС/ЕЭЗ сосредоточили ресурсы общественного здравоохранения на борьбе с COVID-19, чтобы противостоять острому кризису, эти страны продолжали расширять свое участие в EARS-Net. В результате, поскольку данные, представленные в EARS-Net большинством стран, были репрезентативны на национальном уровне, их можно использовать для достоверного описания сохраняющейся угрозы УПП в ЕС/ЕЭЗ.

В 2022 г. ECDC использовал национальные данные, представленные в EARS-Net за 2016–2020 гг., для оценки бремени инфекций, вызванных устойчивыми к антибиотикам бактериями, подлежащими эпиднадзору в ЕС/ЕЭЗ [20]. В период с 2016 по 2019 г. число случаев этих инфекций увеличилось с 685 433 до 865 767, а затем снизилось до 801 517 (по оценке 2020 г.). Расчетное годовое количество смертей, связанных с этими инфекциями, возросло с 30 730 случаев в 2016 г. до 38 710 смертей в 2019 г., а затем немного

снизилось в 2020 г. до 35 813 смертей. В 2016–2020 гг. наибольшее бремя болезней приходилось на инфекции, вызванные штаммами *E. coli*, устойчивыми к цефалоспоринам 3-го поколения, за которыми следовали инфекции, вызванные MRSA и устойчивыми к цефалоспоринам 3-го поколения *K. pneumoniae*. Инфекции, вызванные этими тремя устойчивыми к антибиотикам бактериями, оказали наибольшее воздействие на здоровье, составив 58,2% от общего бремени болезней, измеряемого в потерянных годах здоровой жизни (DALY). По оценкам ECDC, в 2020 г. 30,9% общего бремени, измеренного в DALY, приходилось на инфекции, вызванные бактериями, устойчивыми к карбапенемам. Сходное количество смертей было связано с устойчивыми к карбапенемам *K. pneumoniae* (4 076), *Acinetobacter* spp. (3 656) и *P. aeruginosa* (3 210) [20].

В период с 2020 по 2021 г. особенную тревогу вызывал рост числа зарегистрированных случаев выявления *Acinetobacter* spp. (в странах ЕС/ЕЭЗ в основном комплекса *A. baumannii*), включая изоляты с устойчивостью к карбапенемам. Из всех патогенов, подлежащих эпиднадзору в EARS-Net, *Acinetobacter* spp. второй год подряд демонстрировал наибольший количественный рост. Страны, в которых в 2020–2021 гг. количество случаев инфекции, вызванной *Acinetobacter* spp., значительно увеличилось, также сообщили о высокой процентной доле устойчивых к противомикробным препаратам *Acinetobacter* spp. в годы, непосредственно предшествующие пандемии COVID-19. И наоборот, страны, которые до 2020 г. не сообщали о большом количестве таких случаев или высоких процентных долях УПП, имели в 2021 г. самые низкие показатели, относящиеся к количеству случаев и процентным долям УПП. В странах, где в 2020–2021 гг. число зарегистрированных случаев возросло, большинство вновь выявленных случаев наблюдалось среди пациентов ОРИТ. Большинство полученных у них изолятов были устойчивы к карбапенемам, то есть группе антибиотиков, широко используемых для эмпирического лечения инфекций, связанных с оказанием медицинской помощи [21]. В период 2020–2022 гг. часто сообщалось, что *Acinetobacter* spp. является наиболее распространенной причиной бактериальной коинфекции у госпитализированных пациентов с COVID-19, особенно у пациентов ОРИТ, вызывая в Европе, Северной Америке и на Ближнем Востоке клональные вспышки с высокими показателями летальности, часто связанными с множественной лекарственной устойчивостью [22–25]. Хотя причины повышения числа инфекций, вызванных *Acinetobacter* spp., во многих странах ЕС/ЕЭЗ, требуют дальнейшего изучения, они, вероятно, напрямую связаны с изменениями в системе здравоохранения из-за пандемии. *Acinetobacter* spp. и, в частности, штаммы с множественной лекарственной устойчивостью, как известно, трудно искоренить в больничной среде после того, как они появились. Они выживают на сухих поверхностях, легко загрязняют руки медицинских работников и распространяются бессимптомными носителями [22]. Учитывая беспрецедентный поток пациентов в ОРИТ в странах ЕС/ЕЭЗ в 2020–2021 гг., даже в больницах, которые строго и добросовестно применяли методы ПИИК, все же могли иметь место нарушения ПИИК, достаточные для передачи *Acinetobacter* spp. [11]. Это указывает на необходимость специальных мер по борьбе с *Acinetobacter* spp. в затронутых инфекциями больницах [26]. EARS-Net продолжит сообщать данные о ежегодном заражении *Acinetobacter* spp. в ближайшие «постпандемические» годы, чтобы облегчить оценку тенденций в отношении этого относительно устойчивого больничного загрязнителя.

Учитывая частоту использования аппаратов искусственной вентиляции легких у госпитализированных пациентов с COVID-19, а также тот факт, что источником *P. aeruginosa* часто является окружающая среда, можно было ожидать, что тенденции в отношении случаев инфекции, вызванных *P. aeruginosa*, будут следовать тенденциям, наблюдаемым для *Acinetobacter* spp.; однако они остались относительно неизменными. Это может частично объясняться факторами, связанными с пандемией, например, изменением продолжительности пребывания в больнице и усилением защиты пациентов, подверженных риску как COVID-19, так и инфекции, вызванной *P. aeruginosa*, в частности, пациентов с муковисцидозом. В то же время ECDC не проводит эпиднадзор за заболеваемостью пневмонией и инфекциями нижних дыхательных путей, которые в случае *P. aeruginosa* являются источником в три раза большего числа инфекций, связанных с оказанием медицинской помощи [27].

Для *S. pneumoniae* снижение числа случаев инфекции, наблюдавшееся в 2020 г., продолжилось в 2021 г. и было характерно для всех изолятов, в том числе устойчивых к противомикробным препаратам, охваченным эпиднадзором. Это может быть связано со снижением факторов риска таких инфекций во время волн пандемии COVID-19 (например, снижение частоты межличностных контактов и заболеваемости гриппом, а также назначений антибиотиков и, возможно, более низкая частота посевов крови при внебольничных инфекциях) [3, 28].

Система мониторинга показателей Целей в области устойчивого развития ООН включает два показателя УПП: мониторинг процентной доли инфекций кровотока, вызванных устойчивыми к метициллину *S. aureus* (MRSA) и устойчивыми к цефалоспоринам третьего поколения *E. coli*, у пациентов, обращающихся за медицинской помощью и прошедших тестирование образцов крови [29]. Среди лабораторий в странах ЕС/ЕЭЗ, которые постоянно сообщали данные в течение 2017–2021 гг., процент устойчивости обоих патогенов снизился [9]. Среди лабораторий, которые постоянно сообщали данные за каждый год в течение 2017–2021 гг., тенденция к снижению ежегодного количества изолятов MRSA, зафиксированная в 2019–2020 гг., несколько

изменилась на противоположную в 2020–2021 гг. Однако тенденция к снижению доли устойчивых к цефалоспоринам 3-го поколения изолятов *E. coli* сохранилась [9]. В ЕС/ЕЭЗ эти тенденции также наблюдались для данных по средневзвешенным по численности населения процентным долям УПП в целом (Соединенное Королевство не включено). Стоит отметить, что процентные показатели УПП существенно различаются по странам, что позволяет предположить наличие дополнительных возможностей для их снижения. В частности, до 2020 г. ежегодное снижение доли устойчивых к метициллину штаммов *S. aureus* объяснялось относительно большим и продолжающимся ростом числа зарегистрированных инфекций, вызванных метициллин-чувствительными штаммами *S. aureus* (MSSA); при этом ежегодное число инфекций, вызванных MRSA, оставалось относительно стабильным [30].

При интерпретации данных EARS-Net важно учитывать структуру конкретной системы эпиднадзора, в том числе большие различия в национальных показателях исследования гемокультур и происходящие со временем изменения в системах эпиднадзора. Ограничение EARS-Net, заключающееся в том, чтобы, начиная с 2019 г. и в дальнейшем, рассматривать только данные, полученные с использованием пограничных значений и методологии EUCAST, должно в долгосрочной перспективе улучшить качество и сопоставимость данных. Однако в 2019 г. это привело к тому, что число лабораторий-участников в ряде стран сократилось. Кроме того, систематической оценки характеристик и процентной доли УПП в лабораториях ЕС/ЕЭЗ, которые не сообщают данные в EARS-Net, не проводилось. В итоге, 7 из 29 стран представили данные с охватом менее 50% населения. Таким же образом лаборатории, которые, как было установлено, сообщали данные в течение 5 лет подряд, также могут быть нетипичными по сравнению с другими лабораториями этой же страны. Наконец, как отмечалось выше, на тенденции изменения процентных долей УПП влияют изменения как в системах эпиднадзора в странах, так и в самой сети EARS-Net. Например, более низкий процент устойчивости *P. aeruginosa* к аминогликозидам, зарегистрированный в 2020 и 2021 гг., отражает обновление протокола отчетности EARS-Net для данных за 2020 г. То есть, анализ данных с 2020 г. включает только результаты тестов на чувствительность к тобрамицину, тогда как в предыдущие годы учитывались результаты определения чувствительности к тобрамицину, нетилмицину и гентамицину. Несмотря на эти ограничения, анализ данных эпиднадзора EARS-Net на уровне ЕС/ЕЭЗ, скорее всего, является точным отражением общей ситуации с УПП в этом регионе.

Пандемия COVID-19 привела к появлению ряда нововведений, которые помогут ЕС противостоять угрозам инфекционных заболеваний, включая УПП, а также активизировать действия в области здравоохранения и безопасности здоровья в рамках Европейского союза здравоохранения [31]. Европейский союз здравоохранения обладает широкими полномочиями в отношении деятельности ECDC и Европейского агентства лекарственных средств (EMA), создания Европейского органа по обеспечению готовности и реагированию на чрезвычайные ситуации в области здравоохранения (HERA) и разработки нового Регламента о серьезных трансграничных угрозах для здоровья. Значительно больший бюджет доступен в рамках программы EU4Health (5,3 млрд евро на период 2021–2027 гг.), которая является одним из основных инструментов Европейского союза здравоохранения, относящимся к более широким областям политики и включающим меры по борьбе с УПП.

Отменивший предыдущее Решение (1082/2013/ЕС) новый Регламент Европейского Парламента и Совета ЕС о серьезных трансграничных угрозах для здоровья, принятый 24 октября 2022 г. [32], предоставляет пересмотренную нормативную базу для обеспечения готовности, проведения эпиднадзора, оценки рисков, раннего предупреждения и реагирования на уровне ЕС и государств-членов в случае биологических, химических, экологических или других трансграничных угроз для здоровья [33]. Новые элементы включают разработку плана обеспечения готовности ЕС, систему регулярной оценки национальных планов и укрепление взаимодействия государств-членов в рамках деятельности Комитета по безопасности здравоохранения. Для поддержки национальных референс-лабораторий в государствах-членах Регламент также предусматривает создание референс-лабораторий ЕС, координируемых ECDC и сотрудничающих с референс-лабораториями Всемирной организации здравоохранения (ВОЗ). Референс-лаборатории ЕС будут поддерживать использование сопоставимых методов регистрации заболеваний и отчетность в государствах членах, продвигая использование надлежащих практик и добровольного согласования диагностических методологий. С этой целью деятельность сети референс-лабораторий может быть расширена, охватывая различные направления референс-диагностики, включающие поддержку реагирования на вспышки, предоставление эталонных материалов, внешнюю оценку качества и обучение, научные консультации, сотрудничество и исследования.

Последствия для общественного здравоохранения

Действия общественного здравоохранения по борьбе с УПП в ЕС/ЕЭЗ остаются недостаточно эффективными, несмотря на возросшую осведомленность об УПП как угрозе общественному здоровью и наличие основанных на фактических данных рекомендаций по ПИИК, рациональному использованию противомикробных препаратов и созданию необходимого потенциала для микробиологических исследований. Если правительства более решительно не отреагируют на угрозу УПП, эта проблема будет становиться предметом все большего беспокойства. Оценки, основанные на данных EARS-Net, показывают, что в 2020 г. в ЕС/ЕЭЗ более 800 000 случаев инфекций были вызваны бактериями,

устойчивыми к антибиотикам, и что смерть более 35 000 человек была прямым следствием этих инфекций [20]. По сравнению с периодом до 2020 г. в течение первых 2 лет пандемии COVID-19 (2020–2021 гг.) наблюдалось особенно резкое увеличение числа случаев инфекций, вызванных *Acinetobacter* spp., устойчивых к карбапенемам. Это происходило главным образом в странах, где и до пандемии регистрировался относительно высокий процент случаев устойчивости к этой группе антибиотиков. *Acinetobacter* spp., в том числе устойчивые к карбапенемам изоляты, вызывают вспышки, и эти инфекции трудно искоренить, когда они становятся эндемичными. Учитывая это, вполне вероятно, что в 2022 г. в ЕС/ЕЭЗ рост распространенности устойчивых к карбапенемам *Acinetobacter* spp. продолжится. Варианты обеспечения готовности к вспышкам, их предотвращения и борьбы с ними, описанные в опубликованном ECDC документе по быстрой оценке риска – «Carbapenem-resistant Acinetobacter baumannii in healthcare settings – 8 December 2016» [Устойчивые к карбапенемам Acinetobacter baumannii в медицинских учреждениях – 8 декабря 2016 г.], остаются в силе для больниц и национальных органов власти в странах ЕС/ЕЭЗ [26, 34].

Для борьбы с УПП необходимы срочные дополнительные инвестиции в мероприятия общественного здравоохранения. Это в значительной мере положительно повлияет на здоровье населения и будущие расходы на здравоохранение в ЕС/ЕЭЗ. Подсчитано, что использование комплексного пакета вмешательств, включающего усиленные гигиенические мероприятия, программы рационального использования антибиотиков, кампании в СМИ и применение быстрых диагностических тестов, потенциально могло бы предотвратить в странах ЕС/ЕЭЗ около 27 000 смертей ежегодно. Помимо спасения жизней, такой пакет вмешательств общественного здравоохранения может окупиться в ЕС/ЕЭЗ всего за год и позволит сэкономить в год около 1,4 млрд евро [35].

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1. Antimicrobial resistance – main facts

Antimicrobial resistance

Antimicrobial resistance (AMR) is the ability of a microorganism to resist the action of one or more antimicrobial agents. The consequences of AMR can be severe, and prompt treatment with effective antimicrobials is the most effective way of reducing the risk of poor outcome from serious infections. AMR is one of the biggest threats to public health today, both globally [1] and in the WHO European Region [2,3], leading to mounting healthcare costs, treatment failure and death [4,5].

AMR can occur in different types of microorganisms, including fungi, parasites, viruses and bacteria. This report focuses on AMR in eight common bacterial pathogens of significant public health importance in Europe.

Acquired resistance in bacteria is caused by mutations in chromosomal genes or acquisition of exogenous resistance genes carried by mobile genetic elements that can spread horizontally between bacteria. Bacteria can acquire multiple resistance mechanisms and hence become resistant to several antimicrobial agents. This is particularly problematic as it may severely limit the treatment alternatives available for the infection.

The major drivers behind the occurrence and spread of AMR are the use of antimicrobial agents and transmission of antimicrobial-resistant microorganisms between humans, between animals and between humans, animals and the environment. While antimicrobial use exerts ecological pressure on bacteria and contributes to the emergence and selection of AMR, poor infection prevention and control (IPC) practices favour the further spread of these bacteria. Prudent antimicrobial use and high standards of IPC in all healthcare settings are therefore the cornerstones of an effective response to AMR.

Surveillance of AMR in Europe

The problem of AMR calls for concerted efforts at local and national levels, and for close international cooperation. Surveillance data provide a basis for taking action to control AMR and the importance of data is highlighted in both the WHO European Strategic Action Plan on Antibiotic Resistance for the period 2011–2020 (document EUR/RC61/14, which was adopted by the WHO Regional Committee for Europe at its 61st session in resolution EUR/RC61/R6) [2,3] and the European One Health Action Plan against Antimicrobial Resistance [6]. Surveillance of AMR is listed as a special health issue in the Regulation (EU) 2022/2371 of the European Parliament and of the Council of 23 November 2022 on serious cross-border threats to health [7].

The main international AMR surveillance mechanisms in the WHO European Region are the European Antimicrobial Resistance Surveillance Network (EARS-Net) and the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network. EARS-Net collects data from countries within the European Union and European Economic Area (EU/EEA), while CAESAR collects data from countries within the WHO European Region that are not included in EARS-Net. Through close collaboration and by using compatible methodologies, the two surveillance networks complement one another, contributing to a pan-European overview of the AMR situation.

Facilitated by the WHO Regional Office for Europe and the WHO Collaborating Centre for AMR Epidemiology and Surveillance at the National Institute for Public Health and the Environment (RIVM) in the Netherlands, European data from EARS-Net and CAESAR are also reported to the WHO Global Antimicrobial Resistance Surveillance System (GLASS) [8] to support the WHO Global Action Plan on Antimicrobial Resistance [1].

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2. Technical note

AMR surveillance networks in Europe

EARS-Net

EARS-Net is coordinated by the European Centre for Disease Prevention and Control (ECDC) with the aim of collecting, analysing and reporting data on AMR through a network of national surveillance systems across EU/EEA countries and, as defined in the EARS-Net protocol [1], facilitating action to address AMR.

EARS-Net is based on a network of representatives (ECDC national focal points for AMR, and operational contact points for epidemiology, microbiology and The European Surveillance System (TESSy)/IT data manager interaction for diseases caused by antimicrobial-resistant microorganisms) from EU/EEA countries that collect routine clinical antimicrobial susceptibility test (AST) data from national AMR surveillance initiatives. Participating institutions are listed in Annex 1. Scientific guidance and support is provided by the EARS-Net Disease Network Coordination Committee, which is composed of experts elected from the nominated ECDC national focal points and operational contact points, complemented by observers from organisations involved in AMR surveillance. EARS-Net activities are coordinated in close collaboration with two other ECDC surveillance networks: the European Surveillance of Antimicrobial Consumption Network (ESAC-Net) and the Healthcare-Associated Infections Surveillance Network (HAI-Net). EARS-Net also collaborates with the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and with the European Committee on Antimicrobial Susceptibility Testing (EUCAST), which is supported by ECDC and ESCMID.

In 2021, all EU Member States and two EEA countries (Iceland and Norway) participated in EARS-Net. The number of participating laboratories has increased continuously since the initiation of the network, indicating a strengthening of national AMR surveillance systems in the EU/EEA. The laboratories that participate in the annual EARS-Net external quality assessment (EQA) exercise contribute to improved data quality and an increasing ability of EU/EEA countries to report comparable AMR data [2]. However, the number of laboratories invited to participate in the 2021 EARS-Net EQA may not fully reflect the number of laboratories that provided EARS-Net data for 2021. The results from the EARS-Net EQA for 2021 have been published in a separate report [2].

CAESAR

The CAESAR network was founded in 2012 as a collaborative effort by the WHO Regional Office for Europe, the WHO Collaborating Centre for AMR Epidemiology and Surveillance at RIVM and ESCMID. These institutions participate directly in the activities of the network by having two or three of their experts in the CAESAR coordination group. The goal of the CAESAR network is to assist countries in the WHO European Region (excluding EU/EEA) in setting up or strengthening national AMR surveillance. The CAESAR manual [3] describes the objectives, methods and organisation of the CAESAR network.

As of 2022, 21 countries are engaged in the CAESAR network – Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kosovo[3], Kyrgyzstan, Moldova, Montenegro, North Macedonia, Russia, Serbia, Switzerland, Tajikistan, Türkiye, Turkmenistan, the United Kingdom, Ukraine and Uzbekistan. The number of countries reporting data to CAESAR increased from five in 2013 to 16 in 2021.

The CAESAR network continuously strives to support the establishment of AMR surveillance networks and helps to improve the quality of laboratory test results, manage data, and analyse and report data from existing surveillance networks. The technical assistance provided is tailored to the development phase and the specific needs of each surveillance system. In countries with officially established surveillance systems, emphasis is placed on harmonising laboratory methods and streamlining data management. In those countries where AST is routinely performed in clinical settings but the data are not yet collected at aggregate level, emphasis is placed on setting up a surveillance network and standardising data collection in parallel with the harmonisation of laboratory methods. Finally, in countries that under-utilise bacteriological laboratory diagnostics, the focus is on building laboratory capacity and diagnostic stewardship through the implementation of proof-of-principle projects [4].

Methodology

Antimicrobial susceptibility data

Every year, countries report routine AST results collected from one or more medical microbiology laboratories to ECDC (EARS-Net) and the WHO Regional Office for Europe (CAESAR), as applicable. If it is not possible to include data from all the relevant laboratories, countries can report data from sentinel laboratories. The AMR surveillance for both networks focuses on invasive isolates of eight key bacterial species (*Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Acinetobacter* species, *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Enterococcus faecalis* and *Enterococcus faecium*). CAESAR also collects AST data from invasive isolates of *Salmonella* species, while *Salmonella spp.* are covered separately in EU/EEA countries through the ECDC Food- and Waterborne Disease Network [5]. Other notifiable diseases caused by microorganisms with AMR, such as *Mycobacterium tuberculosis*, are also monitored by the WHO Regional

3 This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the International Court of Justice Opinion on the Kosovo Declaration of Independence.

Office for Europe and ECDC but are not included in CAESAR and EARS-Net.

EARS-Net collects AMR data from EU/EEA countries through TESSy, a web-based platform for data submission and storage hosted by ECDC [6]. CAESAR collects data from WHO European Region countries (excluding EU/EEA) through various secure data-transfer channels. For detailed information on data collection, refer to the EARS-Net reporting protocol [1] and the CAESAR manual [3].

Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net and CAESAR. This restriction aims to reduce the impact of different sampling frames which, to some extent, hamper data interpretation. Any bacterial isolate of the species under surveillance found in a sample taken from a normally sterile body fluid may be considered a pathogen. However, including routine, non-invasive isolates may produce incomparable results for surveillance purposes because the processing of such samples is heavily influenced by clinical interpretation, and diagnostic and treatment guidelines, which vary between countries. Historically, EARS-Net accepted data on isolates from both specimen types for *E. coli*, *K. pneumoniae*, *P. aeruginosa*, *Acinetobacter* spp. and *S. pneumoniae*, but only isolates from blood for *S. aureus*, *E. faecalis* and *E. faecium*. To harmonise data collection between the networks, EARS-Net includes data from both specimen types for all bacterial species under surveillance, starting with 2019 data.

Starting with the data collected for 2019, EARS-Net has only accepted data generated using EUCAST clinical breakpoints and methodology [7]. Before this, the use of EUCAST breakpoints was encouraged, but results based on other interpretive criteria used by reporting countries were also accepted for analysis. CAESAR encourages the use of EUCAST methodology and breakpoints, but accepts data based on other clinical breakpoint guidelines.

From 2020 onwards, EUCAST clinical breakpoints for aminoglycosides indicate isolates with and without acquired resistance mechanisms in systemic infections caused by *E. coli*, *K. pneumoniae*, *P. aeruginosa* and *Acinetobacter* spp., but explicitly note that for these types of infection aminoglycosides should be used in combination with other active therapy.

Correction and re-uploading of historical data by reporting countries is possible. The latest published report therefore supersedes previous reports and reflects the most recent available data. This report is based on data reported to EARS-Net for the period 2017–2021 and retrieved from TESSy on 13 September 2022, as well as data reported to CAESAR for the period 2017–2021, as of 12 September 2022.

Data analysis

Before data analysis, data are de-duplicated to include only the first isolate per patient, year and bacterial species.

Susceptibility test categories

For the analysis, the qualitative susceptibility categories – S (susceptible, standard dosing regimen), I (susceptible, increased exposure) and R (resistant) – are used, as reported by the laboratory, since quantitative susceptibility information is missing for a large part of the data. For laboratories in the CAESAR network using an AST guideline other than EUCAST, the reported qualitative susceptibility categories (S/I/R) have been treated the same way as the susceptibility categories defined by EUCAST, even though these have different microbiological or clinical implications. An isolate is considered resistant to an antimicrobial agent when tested and interpreted as R in accordance with the clinical breakpoint criteria used by the local laboratory. For *P. aeruginosa*, *E. coli*, *K. pneumoniae*, and *Acinetobacter* spp. and some antimicrobial agent combinations presented in this report, EUCAST breakpoints are available for meningitis versus non-meningitis as of 2021. When possible, EU/EEA countries that generate the susceptibility category at national level are recommended to use non-meningitis breakpoints overall as of 2021 data, but EARS-Net accepts data as it is. No recommendations are currently provided to countries reporting to CAESAR concerning use of breakpoints, and CAESAR accepts data as it is. As clinical patient data are not collected in EARS-Net and CAESAR, there is no information available regarding which breakpoint was (likely) used to categorise susceptibility. However, it is assumed that a minority of infections reported to EARS-Net and CAESAR stem from meningitis patients, and it is therefore expected that this does not influence the results to a large extent. The term 'penicillin non-wild-type' is used in this report for *S. pneumoniae*, referring to *S. pneumoniae* isolates reported by local laboratories as I or R to penicillin, assuming minimum inhibitory concentrations (MIC) to benzylpenicillin above those of wild-type isolates (› 0.06 mg/L). Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for the susceptibility categories.

Percentages

AMR/non-wild-type percentages are presented for a single antimicrobial agent and/or group of antimicrobial agents. The bacterial species–antimicrobial agent combinations presented in this report for 2021 are shown in Table 1. When combining results for antimicrobial agents representing an antimicrobial group, the outcome is based on the most resistant result. For example, if the AST result of a bacterial species for imipenem is I and the AST result for meropenem is R, then the AST result for the group carbapenems, which comprises imipenem and meropenem, is set as R. The definition of combined AMR is determined as R to at least one antimicrobial

agent in each of the antimicrobial groups (with the exception of *S. pneumoniae*, for which combined AMR is calculated as combined penicillin non-wild-type and R to macrolides). Isolates with missing data for one or more of the required antimicrobial groups are excluded from the analysis of combined AMR. If fewer than 20 isolates are reported for a specific bacterial species–antimicrobial group combination in a country, the AMR percentage is not displayed in the maps or tables presented in this report.

Population-weighted EU/EEA mean percentage

A population-weighted EU/EEA mean percentage is calculated for each bacterial species–antimicrobial agent combination, based on data reported by EU/EEA countries. Country weightings are used to adjust for imbalances in reporting propensity and population coverage, as in most cases the total number of reported isolates by country does not reflect the population size.

The population-weighted EU/EEA mean percentage is determined by multiplying the AMR percentage for each EU/EEA country with the corresponding national population weight based on the total EU/EEA population and summing up the results. Weights are rescaled if AMR percentages are not available for one or more countries. Annual population data are retrieved from the Eurostat online database [8].

Trend analyses

For EARS-Net, the statistical significance of temporal trends in AMR percentages by country and for the population-weighted EU/EEA (excluding the United Kingdom[4]) mean is calculated based on data from the last five years (2017–2021). EU/EEA countries that did not report data for all years within the period under consideration, or reported fewer than 20 isolates for the specific

4 Please note that as ECDC collects data from EU/EEA Member States, 2017–2019 data was collected by ECDC from the United Kingdom as the United Kingdom was still a Member State of the EU at this time.

Table 1 Bacterial species–antimicrobial agent combinations presented in this report for 2021

Bacterial species	Antimicrobial group/agent or specific resistance mechanism	Antimicrobial agent(s)
E. coli	Aminopenicillins	Ampicillin or amoxicillin
	Third-generation cephalosporins	Cefotaxime, ceftriaxone or ceftazidime
	Carbapenems	Imipenem or meropenem
	Fluoroquinolones	Ciprofloxacin, levofloxacin or ofloxacin
	Aminoglycosides	Gentamicin or tobramycin
K. pneumoniae	Third-generation cephalosporins	Cefotaxime, ceftriaxone or ceftazidime
	Carbapenems	Imipenem or meropenem
	Fluoroquinolones	Ciprofloxacin, levofloxacin or ofloxacin
	Aminoglycosides	Gentamicin or tobramycin
P. aeruginosa	Piperacillin-tazobactam	Piperacillin-tazobactam
	Ceftazidime	Ceftazidime
	Carbapenems	Imipenem or meropenem
	Fluoroquinolones	Ciprofloxacin or levofloxacin
	Aminoglycosides	Tobramycin
Acinetobacter spp.	Carbapenems	Imipenem or meropenem
	Fluoroquinolones	Ciprofloxacin or levofloxacin
	Aminoglycosides	Gentamicin or tobramycin
S. aureus	MRSA	Cefoxitin or oxacillin[a]
	Fluoroquinolones	Ciprofloxacin, levofloxacin or ofloxacin[b]
	Rifampicin	Rifampicin
S. pneumoniae	Penicillins	Penicillin or oxacillin[c]
	Third-generation cephalosporins	Cefotaxime or ceftriaxone
	Fluoroquinolones	Levofloxacin or moxifloxacin[d]
	Macrolides	Azithromycin, clarithromycin or erythromycin
E. faecalis	High-level aminoglycoside resistance	Gentamicin
E. faecium	Aminopenicillins	Ampicillin or amoxicillin
	High-level aminoglycoside resistance	Gentamicin
	Vancomycin	Vancomycin

MRSA: meticillin-resistant *Staphylococcus aureus*.

[a] For EARS-Net, MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA. For CAESAR, MRSA is based on cefoxitin or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[b] For EARS-Net, AST results for norfloxacin are also accepted if neither ciprofloxacin, levofloxacin nor ofloxacin results are available.

[c] Penicillin results are based on penicillin or, if unavailable, oxacillin.

[d] For EARS-Net, AST results for norfloxacin are also accepted if neither levofloxacin nor moxifloxacin results are available.

bacterial species–antimicrobial agent/group combination in any year within the period are not included in the analysis. The statistical significance of trends is assessed by a chi-square test for trend, and a p-value of ‹ 0.05 is considered significant. An additional sensitivity analysis is performed when assessing the significance of the trends by including only laboratories that continuously reported data for the full five-year period, thereby minimising bias due to changes in reporting laboratories over time (by expansion of the surveillance network, for instance). In some cases, this restriction results in a considerably lower number of isolates when compared with the analysis that includes all laboratories.

Like EARS-Net, for CAESAR temporal trends in AMR percentages by country are calculated based on data from the last five years (2017–2021). Trends are not calculated for countries for which AMR data were classified as low for any of the three representativeness indicators (geographical representativeness, hospital representativeness, and isolate representativeness) or for countries where data were not reported for all years within the period under consideration. In addition, as with EARS-Net, trends are not calculated for any specific bacterial species-antimicrobial agent/group combinations for which fewer than 20 isolates were reported in any year within the period under consideration. The statistical significance of trends is assessed by a chi-square test for trend, and a p-value of ‹ 0.05 is considered significant.

Coverage and representativeness of population, hospitals and patients included in EARS-Net/CAESAR

Data sources

For EARS-Net, data on coverage, blood culture sets and representativeness are collected via TESSy from 2018 onwards [1], while data for previous years combine TESSy data with data collected through questionnaires distributed to the ECDC national focal points for AMR.

For CAESAR, an annual assessment of coverage and representativeness is based on information from WHO AMR focal points. They provide an estimate of the population coverage for the sites participating in the respective AMR surveillance network and the geographical and hospital representativeness of the total population. Data on hospital characteristics and numbers of requested blood culture sets are collected using standardised questionnaires [3].

Indicators of coverage and representativeness

Population coverage

Population coverage is expressed as the estimated percentage of the population in an entire country under surveillance by the laboratories contributing data to EARS-Net or CAESAR. For EU/EEA countries, population coverage refers to the percentage of the country's population covered by laboratories reporting to EARS-Net in the specific year. This value should be considered as an indication of the crude population coverage, since the exact percentage of the population under surveillance is often difficult to assess due to overlapping hospital catchment areas and patients seeking care in areas

Table 2 Geographical representativeness, categories and definitions for 2021

Category	Description
High	All main geographical regions of the country are covered.
Medium	Most geographical regions of the country are covered.
Low	Only a few geographical areas of the country are covered.
ND	No data available.

Table 3 Hospital representativeness, categories and definitions for 2021

Category	Description
High	The hospital selection is representative of the acute care hospital distribution in the country.
Medium	The hospital selection is partly representative of the acute care hospital distribution in the country.
Low	The hospital selection is poorly representative of the acute care hospital distribution in the country.
ND	No data available.

Table 4 Isolate representativeness, categories and definitions for 2021

Category	Description
High	The isolate selection is representative of microorganisms causing invasive infections in the hospitals included.
Medium	The isolate selection is partly representative of microorganisms causing invasive infections in the hospitals included.
Low	The isolate selection is poorly representative of microorganisms causing invasive infections in the hospitals included.
ND	No data available.

where they do not reside. For EARS-Net, the population coverage is calculated as the mean of the coverage for the following bacterial species: *E. coli*, *K. pneumoniae*, *P. aeruginosa*, *S. aureus*, *E. faecalis* and *E. faecium*. Due to outliers in some countries, *S. pneumoniae* and *Acinetobacter* spp. are not included in the calculation. For CAESAR, an estimate of the population coverage is based on the best estimates of the overall catchment population for the hospitals included in the country AMR surveillance network, as reported by the respective WHO AMR focal point.

Geographical representativeness

Geographical representativeness is a qualitative indicator referring to geographical coverage. The categories for 2021 are listed and described in Table 2. For EARS-Net the definition was adjusted as of data reported in 2021 [1]. For data reported during the period 2017–2020, the definition of geographical representativeness can be found in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data' [9].

Hospital representativeness

Hospital representativeness is a qualitative indicator referring to the representativeness of hospitals served by the EARS-Net/CAESAR-participating laboratories, compared to the country distribution of hospital types. The categories are listed and described in Table 3.

Isolate representativeness

Isolate representativeness is a qualitative indicator referring to the representativeness of data reported by EARS-Net/CAESAR laboratories in relation to the micro-organisms causing invasive infections in the hospitals included. The categories are listed and described in Table 4. For EARS-Net the collection of data related to isolate representativeness was adjusted as of the data collection in 2022 [1]. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data' [9].

Blood culture rate

Blood culture rate refers to the number of blood culture sets taken per 1000 patient-days in hospitals served by EARS-Net/CAESAR laboratories and sent to these laboratories. For CAESAR, the definitions of a blood culture set and patient-day are provided in the CAESAR manual [3]. Nonetheless for both EARS-Net and CAESAR the definition of a blood culture set and a patient-day may differ between and within countries and this may influence the estimate. For EARS-Net data, blood culture rates are calculated as the mean of the blood culture sets divided by the mean total number of patient-days for hospitals served by laboratories that provided the number of blood culture sets taken for the following bacterial species: *E. coli*, *K. pneumoniae*, *P. aeruginosa*, *S. aureus*, *E. faecalis* and *E. faecium*. Due to outliers in some countries, *S. pneumoniae* and *Acinetobacter* spp. are not included in the calculation. The blood culture rates are presented as the number of blood culture sets taken per 1000 patient-days in hospitals providing AMR data to EARS-Net. For CAESAR, blood culture rates are calculated in a similar manner to EARS-Net, with the exception that *S. pneumoniae* and *Acinetobacter* spp. are included in the calculation. Furthermore, CAESAR provides data on the range of the number of blood culture sets taken per 1000 patient-days across individual hospitals (in parentheses) in addition to the mean.

Isolates from intensive care units

The percentage of isolates reported from intensive care units (ICUs) is calculated for each year and each bacterial species. Isolates with missing information on hospital department are excluded from the calculation, and results are only presented if there are ≥20 isolates, 70% of which have data on hospital department.

Progress indicators for AMR overall coordination and surveillance

Information on the status of the AMR overall coordination and surveillance presented in this report originates from the global tripartite AMR country self-assessment

Table 5 Description of progress indicators of overall coordination on AMR and AMR surveillance

Component	Indicators	Description
Overall coordination on AMR	1. WHO AMR focal point appointed by the Ministry of Health agency	The Ministry/agency appoints an AMR focal point to play a leading role in the formation of an intersectoral coordinating mechanism to contain AMR.
	2. Multisectoral and One Health collaboration/coordination	Based on the One Health approach, a multisectoral coordinating mechanism should be created to contain AMR at national level; this committee ideally should include representatives of relevant government sectors, local professional associations, authorities and leading scientific institutions.
	3. AMR action plan developed	A national AMR action plan is the key document, detailing the characteristics and objectives of the overall national strategy to combat AMR.
AMR surveillance	4. National surveillance system for AMR in humans	Existence of a national surveillance system for identifying patterns and trends of AMR, generating evidence-based clinical guidelines and recognising emerging pathogens.
	5. Submits data to a regional network for AMR surveillance, for the year 2021	Participation in a regional network for AMR surveillance (EARS-Net or CAESAR) for the year 2021.
	6. Participates in a regional EQA scheme, for the year 2021	Participation in a regional EQA scheme (EARS-Net or CAESAR) for the year 2021.
	7. Enrolled in GLASS	Participation in GLASS for the monitoring of AMR on a global scale.
IPC	8. IPC in human healthcare	Status of development and implementation of the main IPC measures at national level.
Antimicrobial stewardship	9. Optimising antimicrobial use in human health	Status of development and implementation of policies and guidelines for antimicrobial stewardship at national level.

survey (TrACSS), coordinated by WHO, the Food and Agriculture Organization of the United Nations and the World Organisation for Animal Health [10]. The survey aims to provide a comparable and periodic assessment of country progress on AMR containment activities in line with the WHO Global Action Plan on AMR. It is designed to be answered through self-assessment and consultation among all the relevant sectors involved. Each country is asked to submit one official response.

The progress indicators selected for this report refer to four main components of AMR activities: overall coordination on AMR; AMR surveillance; IPC and antimicrobial stewardship (Annex 2). A description of the progress indicators is provided in Table 5. Except for indicators 5, 6 and 7, which are derived from the CAESAR, EARS-Net and GLASS databases, all other indicators are based on the results from the sixth round of TrACSS, launched on 9 May 2022 and concluded on 9 September 2022. For the purposes of presentation in this report, information on progress indicators 2, 4, 8 and 9 has been recoded by the WHO Regional Office for Europe using a five-point scale (poor; fair; good; very good; excellent). The original questions and answer categories are reported in Annex 2 and can be accessed via the publicly-available TrACSS database [10].

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3. Overview of antimicrobial resistance in Europe

WHO European Region

This chapter provides an overview of the overall situation and progress related to AMR surveillance in the Region. The indicators chosen represent the main pillars of an AMR surveillance system. The information has mostly been obtained from TrACSS (see Chapter 2). The results are summarised in Table 6.

Progress on overall AMR coordination

Multisectoral and One Health collaboration/coordination

Overall, the results from the TrACSS survey show that when it comes to coordination between the human health sector and the other sectors relevant to AMR – the animal health, food production and environmental sectors – the situation in the WHO European Region is almost evenly split. One group of countries (about 40% of respondents) reported having limited or non-existent mechanisms for intersectoral coordination, while the other group (about 50%) reported carrying out activities jointly, or even adopting an integrated approach to the implementation of the AMR action plan.

National AMR action plan

Among survey respondents, the vast majority 44 (85%) of the 52 countries in the WHO European Region reported having developed an AMR national action plan. This result is encouraging on its own, but of greater importance is the number who have also begun implementing an AMR national action plan: 31 (60%) of the 52 countries. This includes some countries that have a defined monitoring and evaluation process in place, and have made provision for the required financial resources. Some of those who have developed an AMR action plan have also begun implementation, with a defined monitoring and evaluation process in place, and made provision for the required financial resources. Meanwhile, having achieved the first milestone of developing or renewing the action plan, other countries have not been able to operationalise the objectives. This is one of the main challenges for the years to come: supporting countries in the Region to implement the activities included in the AMR action plan, an effort that requires a clear identification of the resources available and broad political support at a higher level.

Progress on surveillance networks and AMR laboratories

National surveillance system for AMR in humans

Results from the survey showed that about 70% of respondents have a national AMR surveillance system for common bacterial infections, with defined standards and coordination from a national reference laboratory and, in some cases, a link to the surveillance system for consumption of antimicrobial medicines. The remaining 30% of respondents reported having a surveillance system for AMR in humans but with limited scope, usually only at local level and lacking national coordination and quality management. This situation was mainly reported among CAESAR members, highlighting the fact that within this network, having a well-functioning and geographically representative system of AMR surveillance that is able to generate reliable information on AMR remains a challenge. In the coming years, renewed efforts and investment will need to be channelled into this objective.

Participation in a regional EQA scheme

The vast majority of the EARS-Net members (26 (90%) of 29 countries in 2021) and CAESAR (17 (86%) of 21 countries) took part in the regional EQA scheme during 2021–2022. This is a remarkable achievement that has been built up over the years through constant support and guidance. The selection of strains used for the EQA exercise is standardised to make it compatible with the epidemiology of the AMR phenotypes of species under surveillance within EARS-Net and CAESAR. There are still some obstacles to making the EQA exercise sustainable - particularly within the CAESAR network - mainly related to logistics and national regulations, which can sometimes restrict the ability to share laboratory sampling and testing panels internationally. These difficulties have been exacerbated by the ongoing war in Ukraine, which is affecting several CAESAR members and their relations with the international community.

Submitted data to a regional network for AMR surveillance

For the 2021 round of reporting, all EARS-Net members submitted AMR data. For CAESAR 16 (76%) of 21 network members submitted AMR data, which is a small increase since the last reporting period. This reflects the state of national surveillance systems. If the surveillance system for AMR is weak or does not have proper geographical coverage, it hampers the possibility of sharing reliable information on AMR. The vast majority of CAESAR members who submit their data to the regional network have a well-established national surveillance network. Substantial improvements in AMR surveillance have been achieved within the CAESAR network through the implementation of laboratory training and the proof-of-principle AMR routine diagnostics surveillance project.

Enrolment in GLASS

As of August 2022, 32 of the 53 members of the WHO European Region are also enrolled in GLASS. This constitutes an important step for international collaboration in reporting and data sharing, and creates opportunities for countries in the Region to receive global support in standardising the collection, analysis and sharing of AMR data. The WHO Regional Office for Europe actively promotes participation in GLASS and will strive to increase enrolment in the coming years.

Progress on IPC programmes and antimicrobial stewardship

IPC in human healthcare

Among the 52 respondents to TrACSS 2022, six (12%) reported having no national IPC programme and nine (17%) reported having IPC and water, sanitation and hygiene health standards that have not been fully implemented. IPC is the key to avoiding the mass spread of infectious diseases – as the COVID-19 pandemic dramatically demonstrated – and is a central tool in curbing AMR. In the coming years, increased efforts in the WHO European Region will be devoted to integrated surveillance that should include IPC as one of its foundational pillars.

Optimising antimicrobial use in human health

Optimising antimicrobial use refers to coordinated efforts of antimicrobial stewardship, including proper diagnostics and appropriate use of antimicrobial drugs; improved patient outcomes; containment of AMR and reduced spread of resistant infections. It is a comprehensive indicator, and it is encouraging that 37 (71%) out of 52 respondents to TrACSS 2022 reported the availability of guidelines for appropriate use of antimicrobials and implementation of antimicrobial stewardship practices in some healthcare facilities. At the same time, there is still much to be done. To exercise real antimicrobial stewardship based on evidence-informed local treatment guidelines, both national and local surveillance data are urgently required – and these can only be obtained with stronger national surveillance systems.

Table 6 Global tripartite AMR country self-assessment survey (TrACSS). Overall coordination and surveillance of AMR in the European Region, 2022

Country	1. WHO AMR focal point appointed by the ministry of health agency	2. Multisectoral and One Health collaboration/coordination	3. AMR action plan developed	4. National surveillance system for AMR in humans	5. Submitted data to a regional network for AMR surveillance, for the year 2021	6. Participated in a regional EQA scheme, for the year 2021/2	7. Enrolled in GLASS	8. IPC in human healthcare	9. Optimising antimicrobial use in human health
Colour code	Yes No	Excellent Very good Good Fair Poor	Yes No/In progress	Excellent Very good Good Fair Poor	Yes No	Yes No	Yes No	Excellent Very good Good Fair Poor	Excellent Very good Good Fair Poor
EU/EEA									
Austria									
Belgium									
Bulgaria	ND								
Croatia									
Cyprus									
Czechia									
Denmark									
Estonia									
Finland									
France									
Germany									
Greece									
Hungary									
Iceland									
Ireland									
Italy									
Latvia									
Liechtenstein	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lithuania									
Luxembourg									
Malta									
Netherlands									
Norway	ND								
Poland									
Portugal									
Romania									
Slovakia									
Slovenia									
Spain									
Sweden									

Table 6 contd

Country	1. WHO AMR focal point appointed by the ministry of health agency	2. Multisectoral and One Health collaboration/coordination	3. AMR action plan developed	4. National surveillance system for AMR in humans	5. Submitted data to a regional network for AMR surveillance, for the year 2021	6. Participated in a regional EQA scheme, for the year 2021/2	7. Enrolled in GLASS	8. IPC in human healthcare	9. Optimising antimicrobial use in human health
Colour code	Yes No	Excellent Very good Good Fair Poor	Yes No/In progress	Excellent Very good Good Fair Poor	Yes No	Yes No	Yes No	Excellent Very good Good Fair Poor	Excellent Very good Good Fair Poor
WHO European Region (excluding EU/EEA)									
Albania									
Andorra	ND				NA	NA			
Armenia									
Azerbaijan									
Belarus									
Bosnia and Herzegovina	ND	ND	ND	ND				ND	ND
Georgia									
Israel					NA	NA			
Kazakhstan									
Kyrgyzstan									
Moldova									
Monaco	ND				NA	NA			
Montenegro				ND				ND	
North Macedonia									
Russia									
San Marino					NA	NA			
Serbia	NA	NA	NA	NA	NA	NA	NA	NA	NA
Serbia excluding Kosovo[1]									
Kosovo[1]	NA	NA	NA	NA				NA	NA
Switzerland									
Tajikistan									
Türkiye									
Turkmenistan									
Ukraine									
United Kingdom									
Uzbekistan									

Note: European Region comprises the 53 countries of the WHO European Region and Liechtenstein.
NA: not applicable.
ND: No data available
[1] This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the International Court of Justice Opinion on the Kosovo Declaration of Independence.

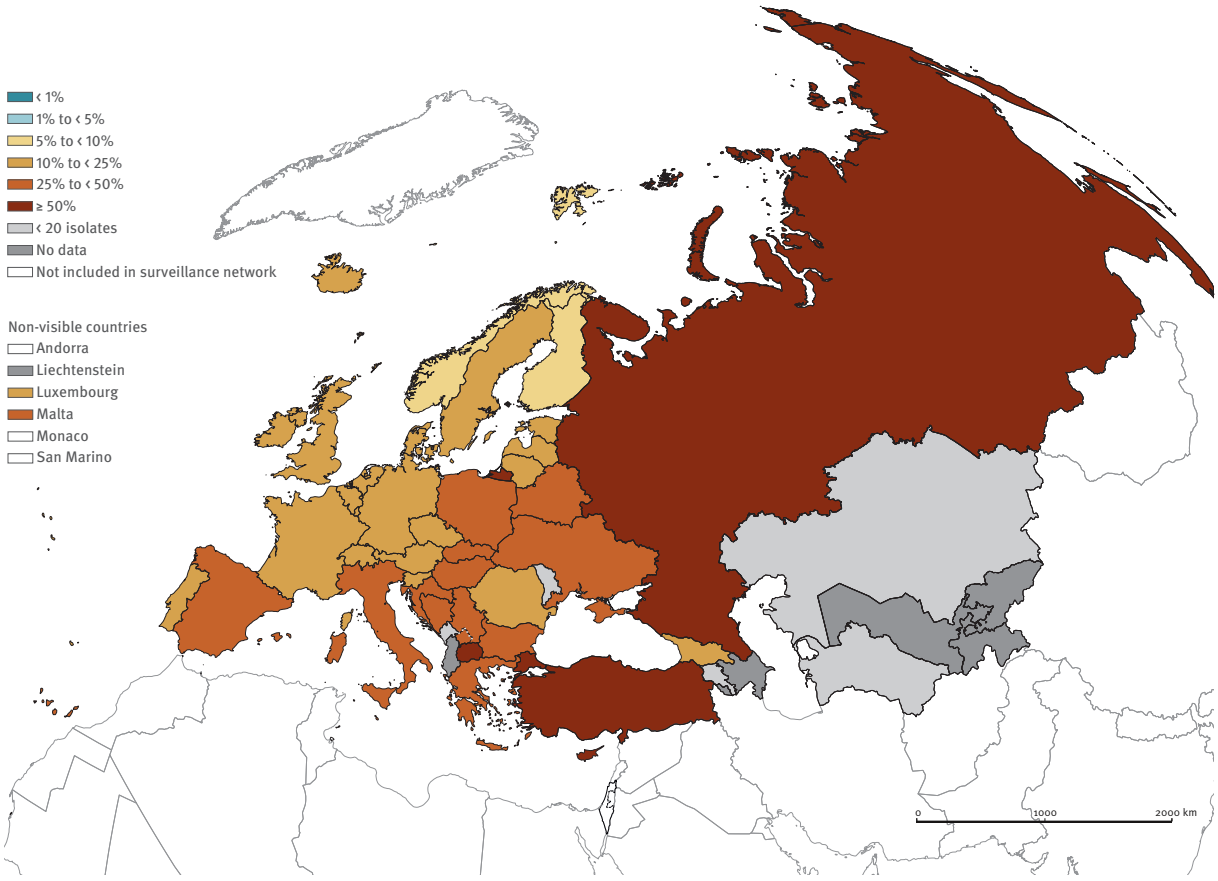
Bacterial species-specific results

Epidemiology

Escherichia coli

E. coli is the most common cause of community-acquired bloodstream infections and urinary tract infections. In 2021, resistance to fluoroquinolones generally was lowest in northern and western parts of the WHO European Region and highest in southern and eastern parts (Fig. 1). An AMR percentage below 10% was observed in two (4%) of 45 countries (Finland and Norway) reporting data on this microorganism. Seventeen countries (38%) reported a percentage of 25% or above. AMR percentages of 50% or above were observed in four (9%) countries (Cyprus, North Macedonia, Russia and Türkiye).

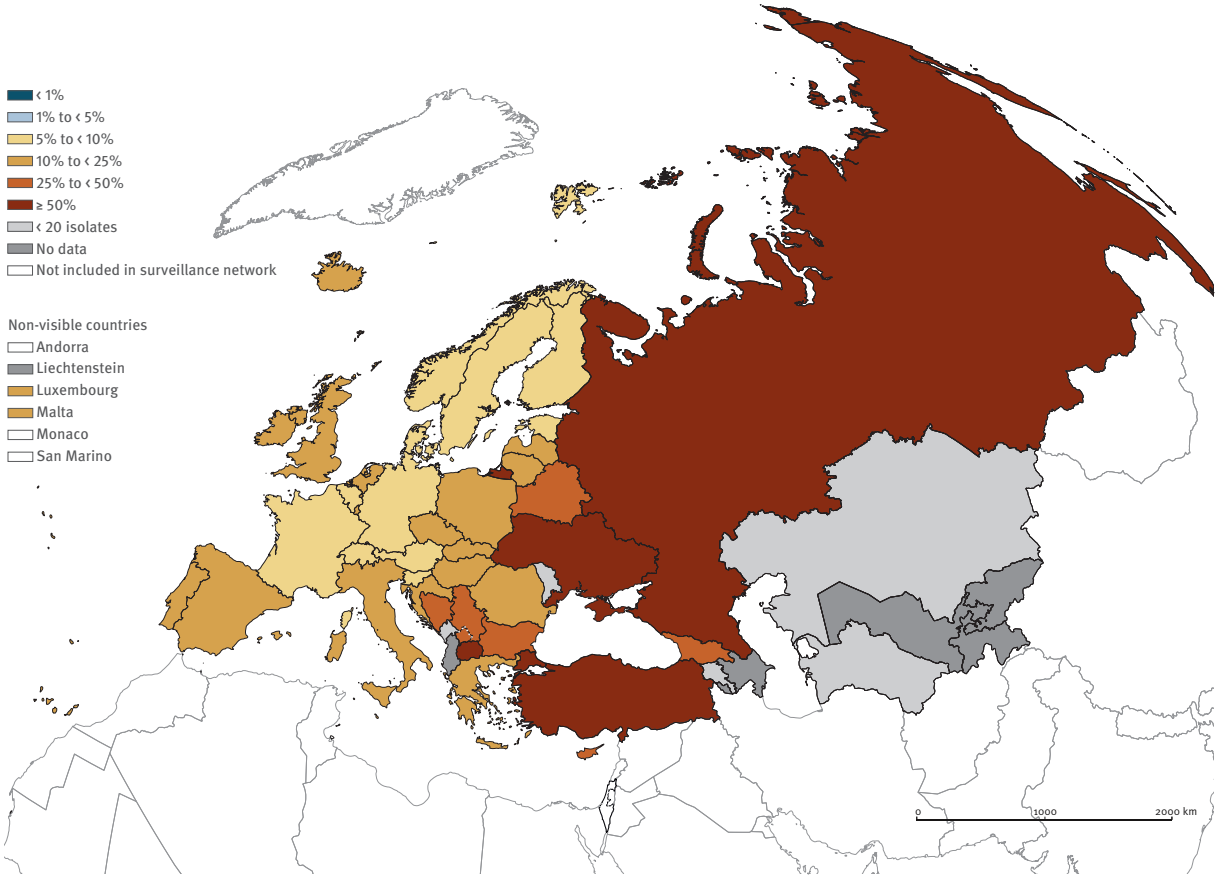
Fig. 1 *Escherichia coli*. Percentage of invasive isolates resistant to fluoroquinolones (ciprofloxacin/levofloxacin/ofloxacin), by country, WHO European Region, 2021



Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).
Map production: ©WHO.

For third-generation cephalosporin resistance in *E. coli*, 12 (27%) of 45 countries reported percentages below 10% in 2021, whereas AMR percentages equal to or above 50% were observed in four (9%) countries (North Macedonia, Russia, Türkiye and Ukraine) (Fig. 2).

Fig. 2 ***Escherichia coli.*** **Percentage of invasive isolates resistant to third-generation cephalosporins (cefotaxime/ceftriaxone/ceftazidime), by country, WHO European Region, 2021**



Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
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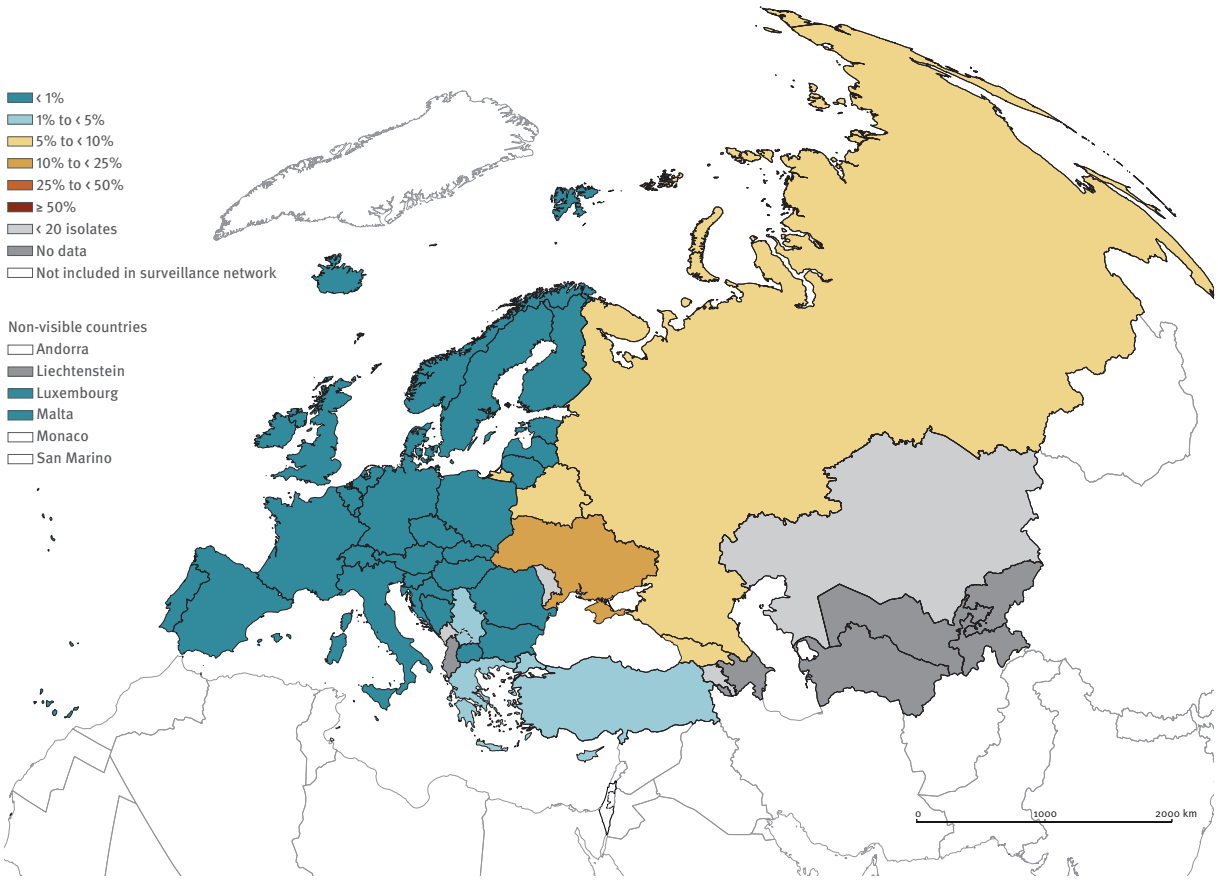
Map production: ©WHO.

The emergence of carbapenem-resistant *E. coli* is of serious concern. Eight (18%) of 44 countries (Belarus, Cyprus, Georgia, Greece, Russia, Serbia, Türkiye and Ukraine) reported percentages of 1% or above in 2021 (Fig. 3).

Fig. 3 *Escherichia coli*. Percentage of invasive isolates resistant to carbapenems (imipenem/meropenem), by country, WHO European Region, 2021

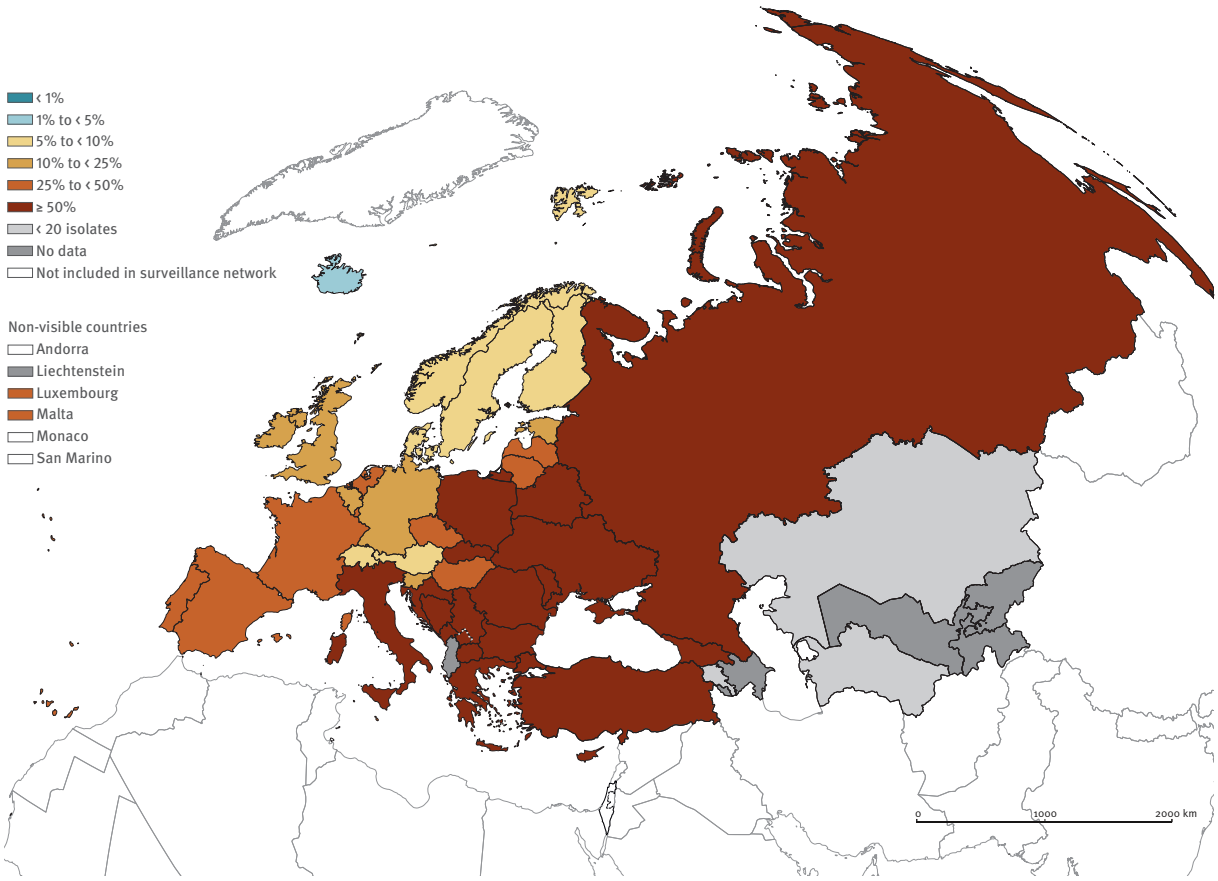


Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).
Map production: ©WHO.

Klebsiella pneumoniae

Like *E. coli*, *K. pneumoniae* is a common cause of bloodstream and urinary and respiratory tract infections and is easily transmissible, leading to a risk of nosocomial outbreaks. Third-generation cephalosporin resistance in *K. pneumoniae* has become quite widespread in the WHO European Region. In 2021, AMR percentages below 10% were observed in seven (16%) of 45 countries reporting data on this microorganism (Austria, Denmark, Finland, Iceland, Norway, Sweden and Switzerland), while 19 (42%), particularly in the southern and eastern parts of the Region, reported AMR percentages of 50% or above (Fig. 4).

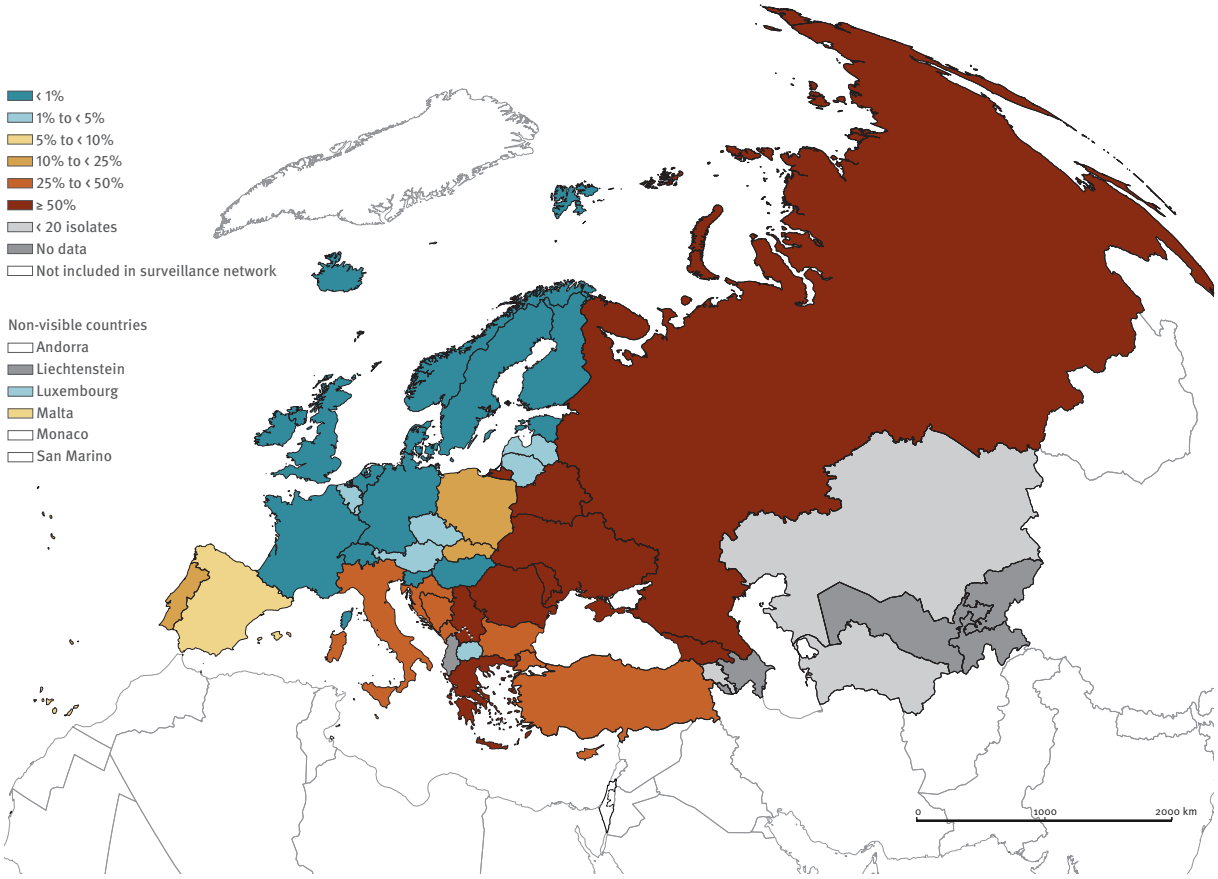
Fig. 4 *Klebsiella pneumoniae*. Percentage of invasive isolates resistant to third-generation cephalosporins (cefotaxime/ceftriaxone/ceftazidime), by country, WHO European Region, 2021



Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).
Map production: ©WHO.

Carbapenem resistance was more frequently reported in *K. pneumoniae* than in *E. coli*. In 2021, percentages were generally low in northern and western parts of the WHO European Region; 14 (31%) of 45 countries reported AMR percentages below 1% (Fig. 5). Fifteen (33%) countries reported percentages equal to or above 25%, eight of which (18% of 45 countries) reported AMR percentages equal to or above 50% (Belarus, Georgia, Greece, Moldova, Romania, Russia, Serbia and Ukraine) (Fig. 5).

Fig. 5 *Klebsiella pneumoniae*. Percentage of invasive isolates resistant to carbapenems (imipenem/meropenem), by country, WHO European Region, 2021

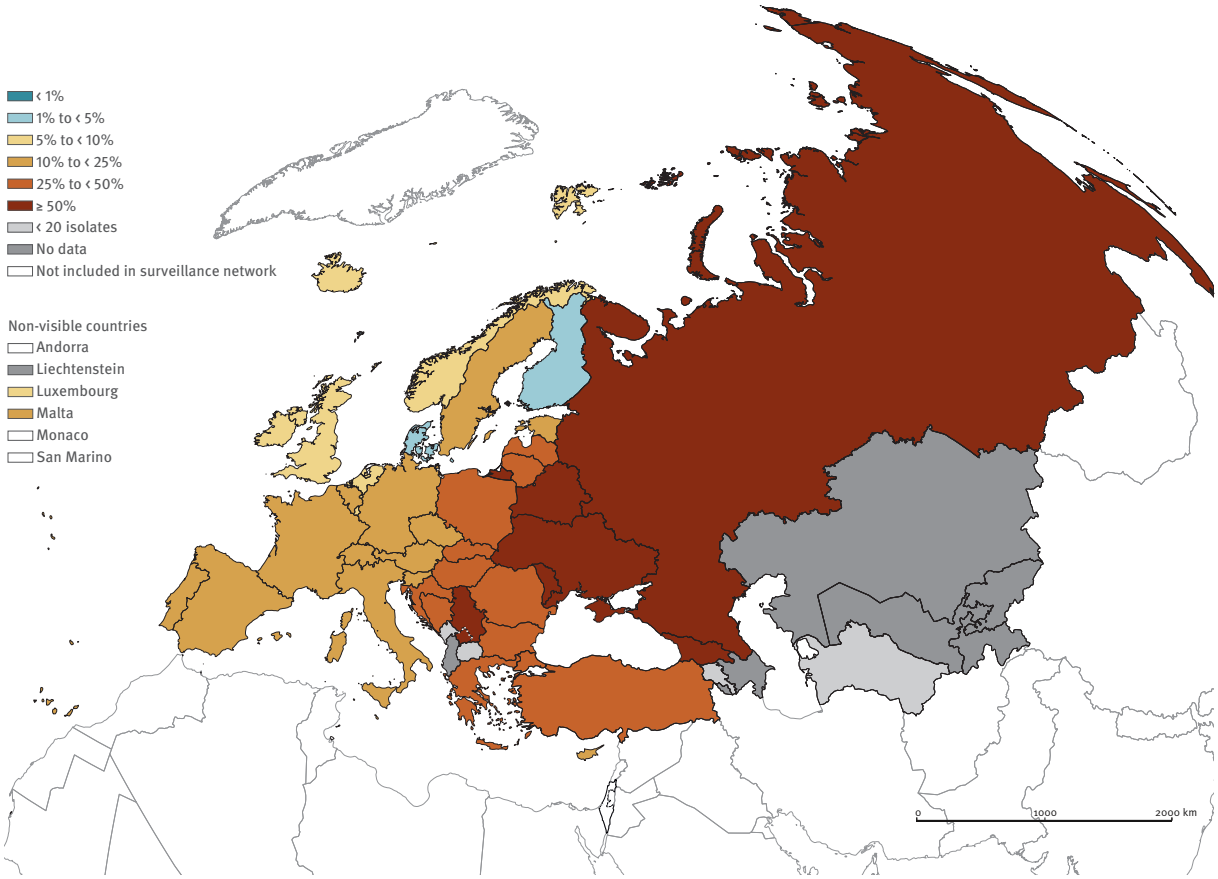


Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).
Map production: ©WHO.

Pseudomonas aeruginosa

P. aeruginosa is a common cause of infection (including hospital-acquired pneumonia, bloodstream and urinary tract infections) in hospitalised patients, especially those with compromised immune defenses. It is intrinsically resistant to many antimicrobial agents and is challenging to control in healthcare settings. Large differences are seen in the percentages of carbapenem-resistant *P. aeruginosa* within the WHO European Region (Fig. 6). In 2021, AMR percentages of below 5% were observed in two (5%) of 44 countries reporting data on this micro-organism (Denmark and Finland), whereas six (14%) countries reported percentages equal to or above 50% (Belarus, Georgia, Moldova, Russia, Serbia and Ukraine).

Fig. 6 *Pseudomonas aeruginosa*. Percentage of invasive isolates with resistance to carbapenems (imipenem/meropenem), by country, WHO European Region, 2021

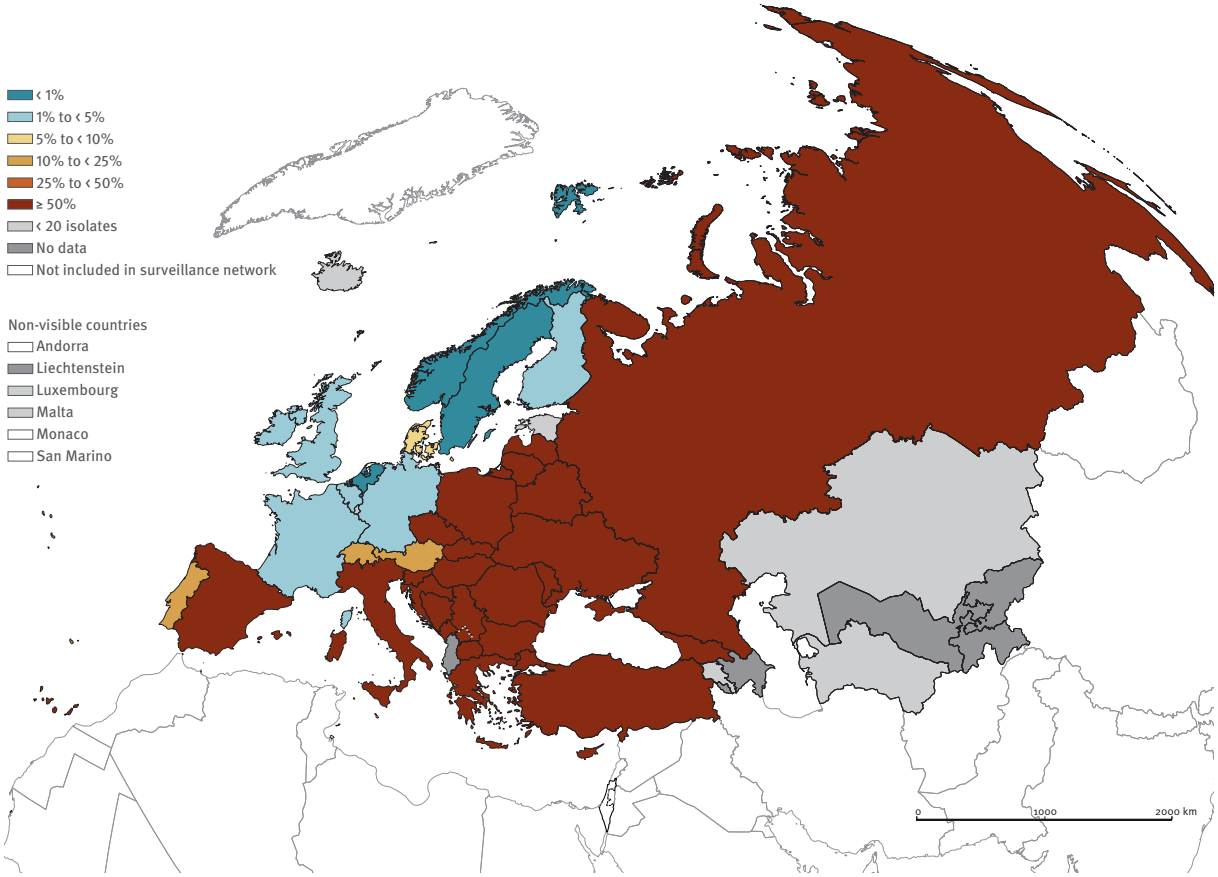


Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).
Map production: ©WHO.

Acinetobacter species

Acinetobacter spp. mainly cause healthcare-associated infections such as (ventilator-associated) pneumonia, (central line-associated) bloodstream infections and postoperative wound infections. *Acinetobacter* spp. can persist in the healthcare environment and are difficult to eradicate once established. The percentages of carbapenem-resistant *Acinetobacter* spp. varied widely within the Region in 2021, from below 1% in three (7%) of 45 countries reporting data on this microorganism (the Netherlands, Norway and Sweden) to percentages equal to or above 50% in 25 (56%) countries, mostly in southern and eastern Europe (Fig. 7).

Fig. 7 *Acinetobacter* species. Percentage of invasive isolates with resistance to carbapenems (imipenem/meropenem), by country, WHO European Region, 2021



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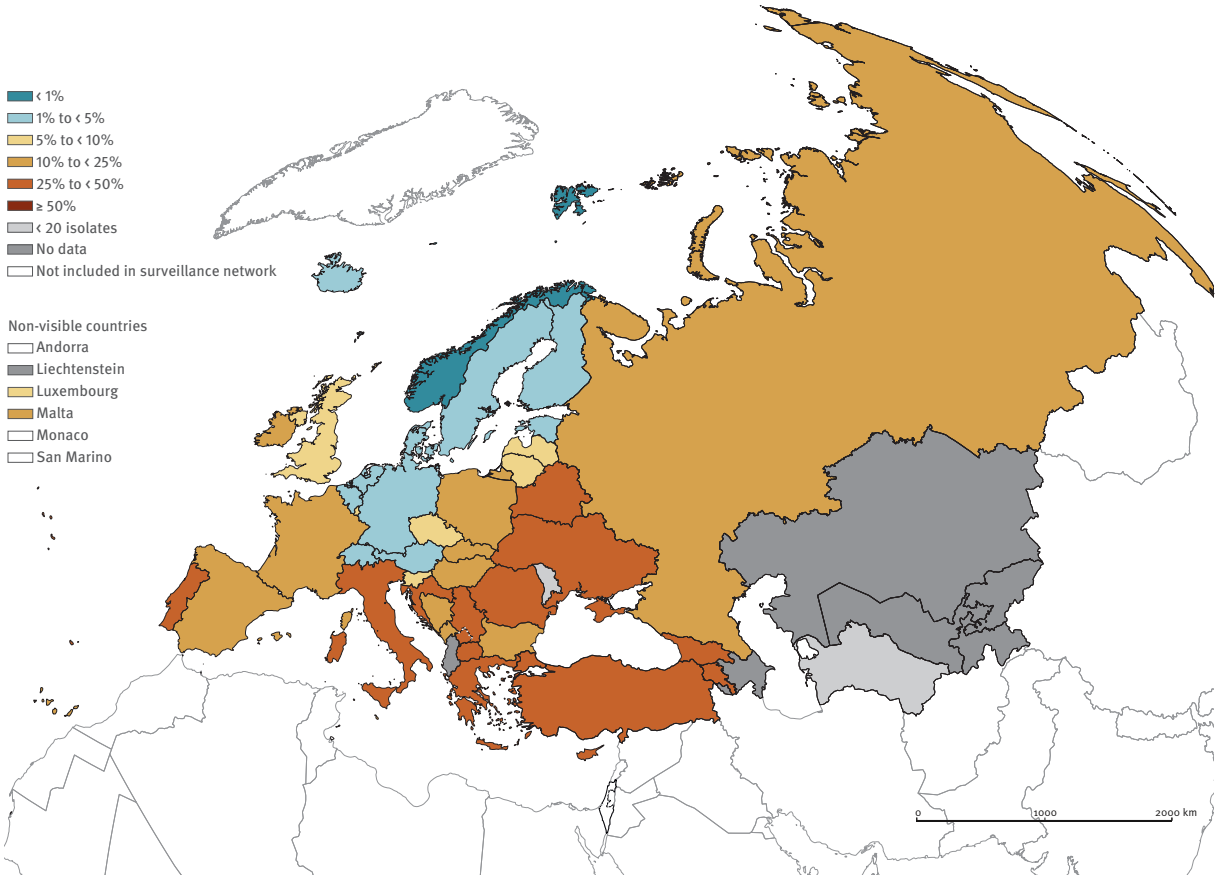
Map production: ©WHO.

Staphylococcus aureus

Meticillin-resistant *Staphylococcus aureus* (MRSA) is one of the most frequent causes of antibiotic-resistant healthcare-associated infections worldwide. In addition, many parts of the world, including Europe, are reporting increasing levels of community-associated MRSA. *S. aureus* mainly causes infections of the skin, soft tissue and bone, and bloodstream. It is the most common cause of post-operative wound infections. In 2021, 11 (25%) of 44 countries reporting data on *S. aureus* had MRSA percentages below 5% (Fig. 8). MRSA percentages equal to or above 25% were found in 13 (30%) countries.

Fig. 8 *Staphylococcus aureus*. Percentage of invasive isolates resistant to meticillin (MRSA),[a] by country, WHO European Region, 2021



[a] For EARS–Net, MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A–agglutionation test) are accepted as a marker for MRSA. For CAESAR, MRSA is based on cefoxitin or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A–agglutionation test) are accepted as a marker for MRSA.

Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.

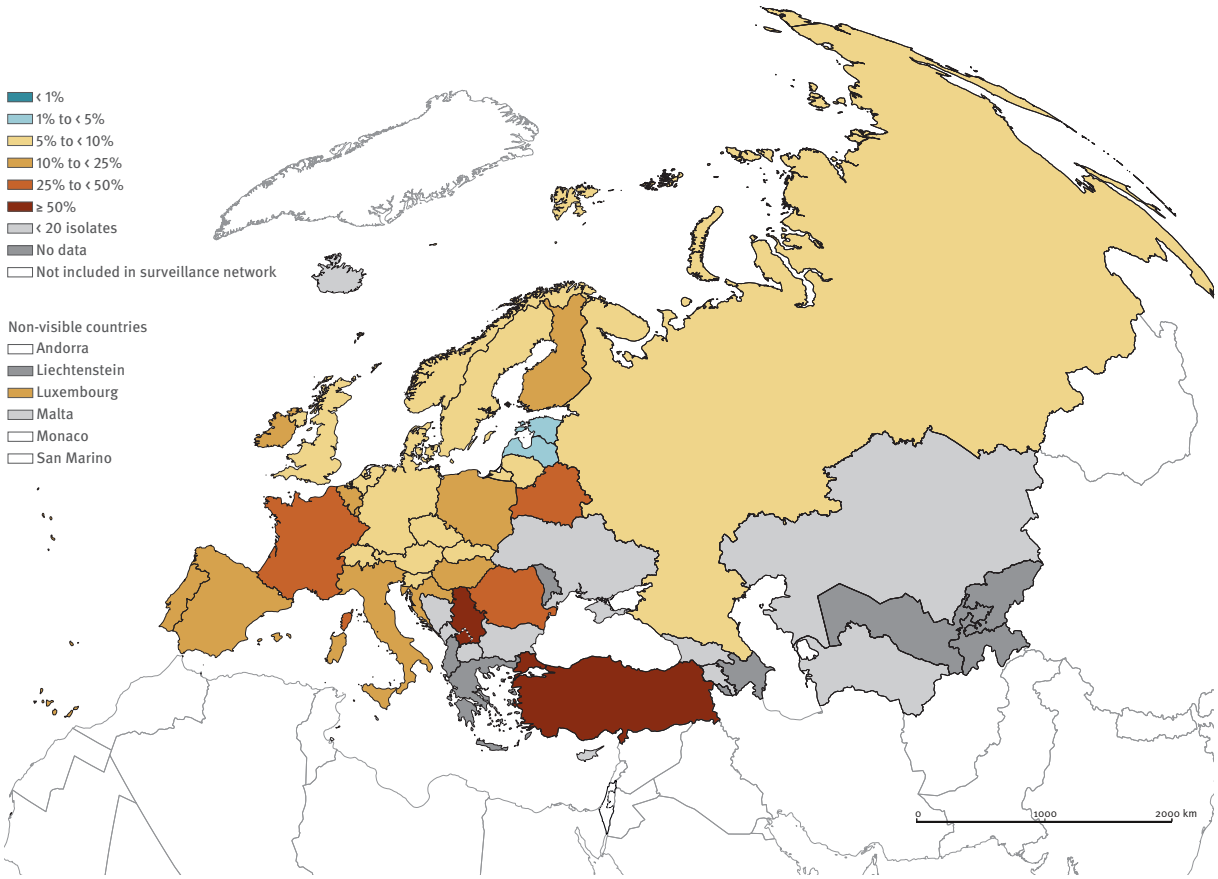
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).

Map production: ©WHO.

Streptococcus pneumoniae

S. pneumoniae causes a wide range of infections, from mild, self-limiting conditions such as otitis media to more serious infections (e.g. community-acquired pneumonia and meningitis), with high mortality in vulnerable patient groups. Large differences were observed across the Region in the percentage of penicillin non-wild-type *S. pneumoniae*. Two (5%) of 43 countries reporting data on this microorganism in 2021 had percentages below 5% (Estonia and Latvia), while percentages equal to or above 25% were found in five (12%) countries (Belarus, France, Romania, Serbia and Türkiye) (Fig. 9).

Fig. 9 *Streptococcus pneumoniae*. Percentage of penicillin[a] non-wild-type[b] invasive isolates, by country, WHO European Region, 2021

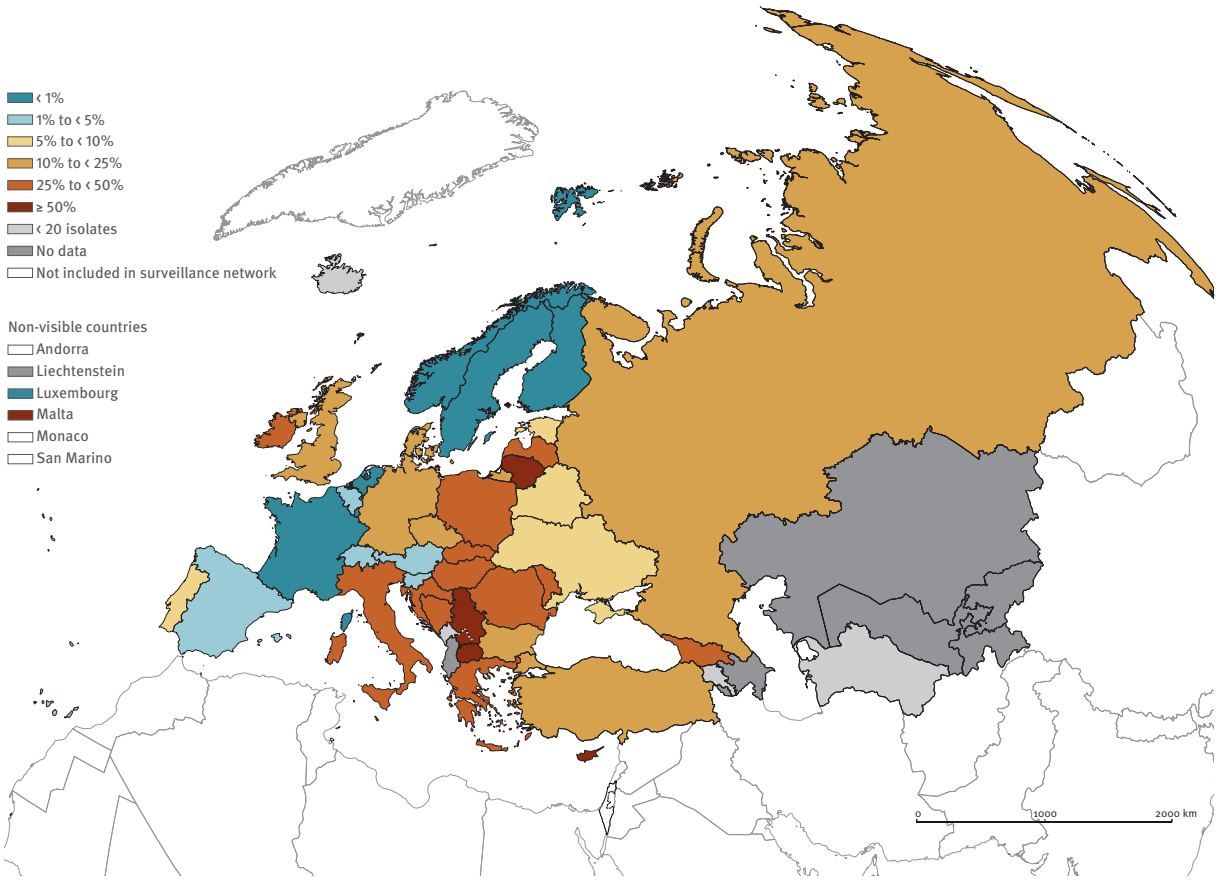


[a] Penicillin results are based on penicillin or, if unavailable, oxacillin.
[b] For *Streptococcus pneumoniae*, the term penicillin non–wild–type is used in this report, referring to *S. pneumoniae* isolates reported by local laboratories as "susceptible, increased exposure" (I) or resistant (R) to penicillin, assuming minimum inhibitory concentrations to benzylpenicillin above those of wild–type isolates (› 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used since quantitative susceptibility information is missing for a large part of the data. It should be understood that laboratories not using EUCAST clinical breakpoints (this applies to only a few laboratories in CAESAR countries/areas in 2021) might define the cut–off values for the susceptibility categories differently.
Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
Data sources: 2021 data from the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR, ©WHO 2021. All rights reserved) and 2021 data from the European Antimicrobial Resistance Surveillance Network (EARS–Net, ©ECDC 2021).
Map production: ©WHO.

Enterococcus faecium

E. faecium is a part of the normal bacterial microbiota of the human gastrointestinal tract. It is usually mildly pathogenic but can, under certain circumstances, cause severe disease such as bloodstream infections, endocarditis and peritonitis. Resistance to vancomycin in *E. faecium* varied substantially among countries in the Region. In 2021, percentages of below 1% were reported by six (14%) of 44 countries providing data on this microorganism (Finland, France, Luxembourg, the Netherlands, Norway and Sweden) (Fig. 10). AMR percentages equal to or above 25% were found in 17 (39%) countries, five of which (11% of 44 countries) reported percentages equal to or above 50% (Cyprus, Lithuania, Malta, North Macedonia and Serbia).

Fig. 10 ***Enterococcus faecium*. Percentage of invasive isolates resistant to vancomycin, by country, WHO European Region, 2021**



Note: Data for Serbia and Kosovo (all references to Kosovo in this document should be understood to be in the context of the United Nations Security Council resolution 1244 (1999)) were combined for this map. Data for the United Kingdom for 2021 includes England, Scotland and Northern Ireland.
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Map production: ©WHO.

Discussion

Despite still adjusting to the challenges posed by the COVID-19 pandemic, 16 countries reported 2021 data to CAESAR, while 29 countries, including all of those in the EU and two from the EEA (Iceland and Norway), reported 2021 data to EARS-Net. In 2021 for the first time, Kazakhstan and Turkmenistan reported data to CAESAR and Ukraine was able to expand its surveillance network, leading to an increase in the number of isolates for all pathogens compared to 2020. Moreover, in 2021 there was an increase in isolates reported to CAESAR per pathogen and overall compared to 2020. Similarly, an increase was observed in the number of isolates reported to EARS-Net overall compared to 2020.

Seven (44%) of the 16 countries reporting data to CAESAR reported that their participating laboratories had an estimated population coverage of over two thirds of the national population, including two countries that reported having an estimated national population coverage of 100%. However, five countries reported data for less than half of their population. Three countries did not report data (Table A3.2).

One (6%) of the 16 countries reporting data to CAESAR indicated that their reported data had a high national representativeness, in terms of three metrics: geographical representativeness, hospital representativeness, and isolate representativeness. A further eight countries reported that the representativeness was 'high' for two of these three metrics, and three countries reported that the representativeness of their national data was 'low' for all three metrics (Table A3.2).

The blood culture rate, in hospitals served by the laboratories that reported data to CAESAR in 2021, was reported by 13 countries. For the one country that reported a high national representativeness according to all three metrics listed above, no data was available on the national average blood culture rate. In the eight countries reporting a high national representativeness (according to two of the three metrics listed above) with data available on the national average blood culture rate, the national average blood culture rate was 2.3-fold higher than in the five countries reporting a medium or low national representativeness (according to at least two of the three metrics) with data available on the national average blood culture rate (20.9 versus 9.2 blood culture sets per 1000 patient-days, respectively). Comparative findings for the EU/EEA are included in the section 'Overall EU/EEA situation'.

The results from CAESAR and EARS-Net clearly show that AMR continues to be widespread in the WHO European Region. The results presented in this report originate from distinct country surveillance systems that are characterised by specific protocols and practices, which limits inter-country comparability. Despite these limitations, the presence of specific AMR patterns across clinical settings covered by the surveillance networks is apparent. High percentages of resistance to third-generation cephalosporins in *E. coli*, high percentages of resistance to third-generation cephalosporins and carbapenems in *K. pneumoniae*, high percentages of carbapenem-resistant *Acinetobacter* spp., and high percentages of MRSA in several countries are of concern. These findings suggest the dissemination of resistant clones in healthcare settings and indicate the serious limitations in treatment options faced by many countries for patients with infections caused by these pathogens. They also indicate that IPC measures require rigorous attention. While there is an evident west-to-east gradient in AMR percentages for gram-negative bacteria (*E. coli*, *K. pneumoniae*, *P. aeruginosa* and *Acinetobacter* spp.), it is less obvious for gram-positive bacteria (*S. aureus*, *S. pneumoniae* and *E. faecium*). As antimicrobial-resistant bacterial microorganisms cannot be contained within borders or regions, these results underline the need for concerted action to combat AMR throughout the WHO European Region, and globally.

In addition, an increase in resistance to third-generation cephalosporins in *K. pneumoniae* was observed, and to carbapenems in *K. pneumoniae*, *P. aeruginosa*, and *Acinetobacter* spp. in Bosnia and Herzegovina and Serbia. Türkiye experienced a similar increase in these combinations, with the exception of carbapenems in *P. aeruginosa*. The United Kingdom experienced an increase in resistance to third-generation cephalosporins in *K. pneumoniae* and to carbapenems in *P. aeruginosa*, and a decrease in resistance to carbapenems in *K. pneumoniae*. Overall, this increased resistance to third-generation cephalosporins in *K. pneumoniae*, and to carbapenems in *K. pneumoniae* and *Acinetobacter* spp. was also observed in the EU/EEA.

In terms of isolates reported to CAESAR, considering only the countries that submitted data both in 2020 and 2021 (13 countries), there was a 26% increase in *E. coli* isolates, a 36% increase in *K. pneumoniae* isolates, a 41% increase in *P. aeruginosa* isolates, a 50% increase in *Acinetobacter* spp., and a 22% increase in *S. pneumoniae* isolates in 2021, compared to 2020. There was also a 30% increase in *S. aureus* isolates, a 32% increase in *E. faecalis* isolates, and a 41% increase in *E. faecium* in 2021 compared to the previous year. In fact, the increase in *Acinetobacter* spp. isolates was also observed in 2020. This increase in isolates for *Acinetobacter* spp., mostly *A. baumannii* complex, was also one of the most obvious findings in the EU/EEA in 2021.

Since the publication of the Global Action Plan on Antimicrobial Resistance (GAP-AMR) in 2015 [1], most Member States of the WHO European Region have enhanced efforts to tackle AMR by ensuring costing and implementation of national action plans (NAP) across sectors. Progress has been made on this front, with 44 (85%) of the 52 countries in the Region reporting having developed a NAP on AMR in the latest round of global monitoring, compared to 34 (68%) of the 50 countries reporting this in 2017 [2]. One of the largest remaining challenges is to ensure adequate funding for implementation of NAPs, with packages of effective intervention to combat AMR. A staggering 40 (77%) of

52 countries reported governance and administrative impacts, such as reduced funding, as a consequence of the COVID-19 pandemic [2]. Although it is one of the key objectives of the GAP-AMR, surveillance still struggles to reach adequate and sustainable capacity in the WHO European Region: 16% of countries still reported collecting AMR data only at local level, without a standardised approach. This further warrants a call for continued coordinated action and commitment globally.

Similarly, efforts to improve antimicrobial consumption in the Region remain heterogeneous. During 2021, 19 (68%) of 28 EU/EEA countries reporting data for both the community and the hospital sector met or exceeded the WHO country-level target of 60% of total antibacterial consumption being derived from WHO's Access category (as defined in the Access, Watch, Reserve (AWaRe)[5] classification list) [3]. Only five countries of 18 reporting to the WHO Regional Office for Europe Antimicrobial Medicines Consumption Network achieved this target in 2019 [4].

Public health implications

AMR is one of the top 10 global public health threats facing humanity [5]. While the number of countries in the Region that followed the global call [1, 6] to develop NAP-AMRs has reached a high level, and many countries are already embarking on a revision of their NAPs for the next phase of implementation, there are also countries that have only just started out on the path to implement effective interventions to tackle AMR. The same applies to AMR surveillance: greater efforts and investment are required to increase the comparability, quantity and quality of AMR surveillance data. Current patterns, such as increases in carbapenem-resistant *Acinetobacter* spp. isolates that are difficult to eradicate once endemic, indicate that efforts to prevent and detect resistance should be enhanced. These patterns also highlight the role AMR surveillance can play in strengthening health system resilience and preparedness.

High-level support and robust funding for comprehensive programmes and interventions on IPC, antimicrobial stewardship and surveillance are still inadequate. It is clear that commitment at the highest-level of government is crucial to advance the AMR agenda [7].

The COVID-19 pandemic exposed the weaknesses in national health systems and the interconnectedness of countries and continents. In fact, the impact of the pandemic on AMR NAPs can be seen from the results of the 2022 TrACSS survey: 43 (90%) of the 48 participating countries in the Region reported their AMR NAP development and implementation being affected by the pandemic; 40 (77%) of 52 countries reported impacts on governance and administration, such as reduced funding; 38 (73%) of 52 countries reported operational impacts such as increased antibiotic use [2]. At the same time, evidence from the Region suggests that facilities with robust antimicrobial stewardship (AMS) programmes in place were able to gradually normalise AMS programme activity after the first wave of the pandemic and control the level of antibiotic use in the long run [8].

The world is still adjusting to the effects of the pandemic on people and public health, and efforts to tackle AMR are only just beginning to find a balance after the reorganisation of healthcare professionals to support the COVID-19 response across the European Region. Across the globe, governments were confronted with the need to take more coordinated action. This paved the way for a more united front against future health threats, including that of AMR. It stands to reason that such a united front will respond more robustly to the looming threat of AMR in the future. In fact, on 13 December 2021, the goal of strengthening preparedness against the 'silent pandemic' of AMR was agreed upon by all G7 Finance Ministers [9].

This report highlights the persistent disparities in AMR prevalence across the WHO European Region and reveals unexploited opportunities for counteracting AMR.

5 AWaRe classifies antibiotics into three stewardship groups – Access, Watch and Reserve – to emphasise the importance of their optimal uses and potential for AMR.

EU/EEA countries

Overall EU/EEA situation

As in the preceding years, all EU Member States and two EEA countries (Iceland and Norway) reported data for 2021 from invasive isolates (retrieved from blood or cerebrospinal fluid) to EARS-Net [10]. Eighteen (62.1%) of these 29 countries reported that their participating laboratories had a population coverage of over two-thirds of the national population, including 14 countries that reported having a national population coverage of 90.0% or more. However, seven countries reported data for less than half of their population (Table A3.2).

Twenty-two (75.9%) of the 29 participating countries classified the national representativeness of their reported EARS-Net data as high, in terms of three metrics: the covered geographical areas, the included acute care hospitals, and the microorganisms that caused invasive infections in those hospitals. A further three countries reported that the representativeness was 'high' for two of the three metrics, and one country reported that the representativeness of its national data was 'low' for all three metrics (Table A3.2).

The blood culture rate, in hospitals served by the laboratories that reported data to EARS-Net in 2021, was reported by 24 countries. In the 22 countries that reported a high national representativeness according to all three metrics listed above, the rate at which blood cultures were obtained for patients was 2.6-fold higher than in the four countries that reported one or none of the metrics of national representativeness as high (76 versus 29 blood culture sets per 1000 patient-days, respectively). The reported blood culture rates were highest in Belgium, Denmark, Finland, Portugal, and Spain (› 100 sets per 1000 patient-days), and lowest in Bulgaria, Czechia, Hungary, Latvia and Lithuania (‹ 25 sets per 1000 patient-days) (Table A3.2). Appropriate microbiological testing of blood samples is a pre-requisite for adjusting the appropriateness of antimicrobial prescriptions to treat infections, and for reducing AMR.

All but one country reported data for all eight bacterial species under EARS-Net surveillance (*E. coli*, *K. pneumoniae*, *P. aeruginosa*, *Acinetobacter* spp., *S. pneumoniae*, *S. aureus*, *E. faecalis* and *E. faecium*), while one country (Greece) reported data for all bacterial species except *S. pneumoniae*.

The number of laboratories participating in EARS-Net continued to increase, indicating a strengthening of national AMR surveillance systems in the EU/EEA. In 2021, 1847 laboratories reported data, 1006 of which were in France. There were 666 laboratories identifiable as having reported data for each year during the period 2017–2021, as the reporting countries were able to provide a consistent laboratory identifier. These do not include › 85.0% of the laboratories in France and Greece that participated in 2021, either because there were major changes in the organisational structure of the national surveillance system (France), or because of the restriction of EARS-Net, starting with 2019 data, to only include laboratories using EUCAST methods and guidelines (Greece).

Overall in 2021, the most commonly reported bacterial species was *E. coli* (39.4% of all reported cases), followed by *S. aureus* (22.1%), *K. pneumoniae* (11.9%), *E. faecalis* (8.8%), *E. faecium* (6.2%), *P. aeruginosa* (6.1%), *Acinetobacter* spp. (3.0%) and *S. pneumoniae* (2.5%). This ranking is different to 2020, since *E. faecium* and *Acinetobacter* spp. are one rank higher. Between 2020 and 2021, the number of reported cases increased for all pathogens. The largest increases were observed for *Acinetobacter* spp. (+43.2%), *E. faecium* (+20.5%) and *E. faecalis* (+14.0%), with smaller increases for *S. aureus* (+9.4%), *P. aeruginosa* (+8.2%), *K. pneumoniae* (+8.1%), *S. pneumoniae* (+4.3%), and the most frequently reported pathogen – i.e. *E. coli* (+2.8%).

During 2020 and 2021, reporting of cases of pathogens with AMR coincided with changes in healthcare and the community resulting from the global COVID-19 pandemic, which will have affected IPC activities targeting these pathogens. Therefore, a comparison of 2021 data with data from the years immediately before 2020 is informative. In addition, even though the national and EU/EEA representativeness of EARS-Net data is high, restricting analysis to laboratories known to have reported continuously throughout the period 2017–2021 is a way of verifying trends. This `restricted' dataset is very similar to the 'full' dataset. To illustrate this point, the overall number of isolates at EU/EEA level, for all bacterial species under surveillance, increased by 7.2% in 2021 compared to 2020 among laboratories that continuously reported data to EARS-Net during 2017–2021. This number increased by 8.8% in all laboratories that reported during that period. Similarly, among the `restricted' set of laboratories that continuously reported data during the period 2017–2021 *S. pneumoniae* was reported more frequently than *Acinetobacter* spp. (3.2% and 2.8% of all reported bacterial species, respectively), but otherwise the ranking remained the same as in the full dataset. Within that same restricted group of laboratories, comparing 2021 to the average for 2018 and 2019, the largest increases in the number of reported isolates were for *Acinetobacter* spp. (+73.9%; 3523 and 6127, respectively) and *E. faecium* (+32.5%; 9926 and 13151, respectively) followed by *E. faecalis* (+11.7%; 15777 and 17620, respectively). There was almost no change in *K. pneumoniae* (+0.03%; 25044 and 25052, respectively) and *P. aeruginosa* (-0.9%; 12150 and 12035, respectively), and a decrease in the number of reported isolates of *S. aureus* (-5.5%; 50267 and 47487, respectively), *E. coli* (-11.8%; 99266 and 87526, respectively), and in particular *S. pneumoniae* (-45.6%; 12629 and 6875, respectively) [11].

In 2021, the most striking observation was the overall increase in the number of *Acinetobacter* spp., which mostly belong to the *A. baumannii* complex in the EU/EEA. This does not appear to be a feature of improved

Table 7a Total number of invasive isolates tested (n) and percentage of isolates with AMR phenotype (%) in EU/EEA[a], by bacterial species and antimicrobial group/agent, population-weighted EU/EEA[a] mean, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA country range[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	125866	58.7	133700	57.5	130603	57.1	107371	54.6	108730	53.1	31.7–70.2
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	140584	14.9	152720	15.1	157918	15.1	139057	14.9	143180	13.8	5.5–37.3
	Carbapenem (imipenem/meropenem) resistance	140438	0.1	151444	0.1	156871	0.3	135624	0.2	137526	0.2	0.0–1.1
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	141562	25.7	154698	25.3	161718	23.8	139372	23.8	143253	21.9	9.6–51.6
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[c]	141788	11.4	154266	11.1	161432	10.8	136101	10.9	139435	9.6	4.1–27.0
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[c]	135108	6.3	148206	6.2	154844	5.9	134115	5.7	137757	5.1	1.2–14.8
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	32952	31.2	38420	31.7	41057	31.4	39848	33.9	43261	34.3	3.4–81.4
	Carbapenem (imipenem/meropenem) resistance	32960	7.1	38140	7.5	40714	8.0	39279	10.0	42007	11.7	0.0–73.7
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	32908	31.5	38754	31.6	41617	31.3	40066	33.9	43136	33.6	0.0–80.0
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[c]	33119	24.1	38539	22.7	41484	22.4	38977	23.7	42181	23.7	0.0–69.1
	Combined resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides[d]	31597	20.5	37386	19.6	40270	19.4	38331	21.0	41590	21.2	0.0–67.4
P. aeruginosa	Piperacillin-tazobactam resistance	16414	16.7	18607	16.8	19465	17.0	19799	18.8	21419	18.7	0.0–47.2
	Ceftazidime resistance	16481	14.6	18948	14.1	19959	14.3	20122	15.5	21750	15.8	2.3–46.0
	Carbapenem (imipenem/meropenem) resistance	17078	17.2	19221	17.2	20238	16.6	20517	17.9	22267	18.1	3.5–45.9
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	16920	20.0	19199	19.7	20384	18.9	20425	19.6	22129	18.7	3.3–48.0
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	16948	13.1	19174	11.8	20344	11.5	12880	9.4	14537	8.9	0.0–41.7
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[d]	15448	12.7	17890	12.7	18630	12.2	12041	13.6	13684	12.6	0.0–42.1
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	6171	33.1	6512	31.9	5927	32.4	7507	37.9	10732	39.9	0.0–99.5
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	6087	37.4	6474	36.2	5888	36.6	7372	41.7	10626	43.0	1.5–99.8
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[c]	6042	32.2	6437	31.3	5891	32.8	7275	37.0	10399	39.6	2.1–98.8
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[c]	5872	28.2	6283	28.3	5668	29.4	7111	34.0	10172	36.8	0.0–98.5
S. aureus	MRSA[e]	66279	16.9	72882	16.4	74718	15.7	72976	16.7	78633	15.8	0.9–42.9
S. pneumoniae	Penicillin non-wild-type[f]	17182	12.8	18660	12.9	18235	12.2	8076	15.5	8465	16.3	3.6–35.7
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	17575	15.7	19203	15.2	18940	14.5	8407	16.8	8758	18.3	0.0–36.0
	Combined penicillin non-wild-type and resistance to macrolides[f]	16554	8.1	18068	7.8	17529	7.3	7782	8.9	8141	9.9	0.0–28.0
E. faecalis	High-level gentamicin resistance	13930	29.7	15343	27.1	13577	25.3	14316	29.0	16301	29.0	6.7–55.2
E. faecium	Vancomycin resistance	14183	15.0	15961	17.3	16523	18.3	18349	16.8	22315	17.2	0.0–66.4

[a] Number of EU/EEA countries: 30 in 2017-2019, 29 in 2020-2021 (excluding the United Kingdom).
[b] Lowest and highest national AMR percentage among reporting EU/EEA countries.
[c] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[d] The aminoglycoside group includes only tobramycin from 2020 onwards.
[e] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[f] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by local laboratories as susceptible, increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (› 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Table 7b Total number of invasive isolates tested (n) and percentage of isolates with AMR phenotype (%) in EU/EEA (excluding the United Kingdom), by bacterial species and antimicrobial group/agent, population-weighted EU/EEA mean and trend (excluding the United Kingdom), 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA country range[a]	Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	97219	58.1	104198	57	102375	56.6	107371	54.6	108730	53.1	31.7–70.2	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	112659	15.6	124043	15.7	131325	15.6	139057	14.9	143180	13.8	5.5–37.3	↓*
	Carbapenem (imipenem/meropenem) resistance	110364	0.1	120215	0.1	127262	0.3	135624	0.2	137526	0.2	0.0–1.1	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	111377	26.9	123358	26.4	132015	24.7	139372	23.8	143253	21.9	9.6–51.6	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[c]	111049	11.6	122147	11.2	130984	10.8	136101	10.9	139435	9.6	4.1–27.0	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones, and aminoglycosides[c]	108300	6.6	120450	6.4	129083	6.1	134115	5.7	137757	5.1	1.2–14.8	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	27979	34.1	33239	34.4	36190	34.1	39848	33.9	43261	34.3	3.4–81.4	-
	Carbapenem (imipenem/meropenem) resistance	27686	8.1	32548	8.5	35439	9.0	39279	10.0	42007	11.7	0.0–73.7	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	27615	34.7	33154	34.3	36315	34.0	40066	33.9	43136	33.6	0.0–80.0	↓
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[c]	27756	26.4	32830	24.7	36078	24.5	38977	23.7	42181	23.7	0.0–69.1	↓*
	Combined resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides[c]	26837	22.9	32381	21.6	35622	21.5	38331	21.0	41590	21.2	0.0–67.4	↓
P. aeruginosa	Piperacillin-tazobactam resistance	13717	18.3	16018	18.5	16894	18.6	19799	18.8	21419	18.7	0.0–47.2	-
	Ceftazidime resistance	13801	16.0	16327	15.5	17328	15.7	20122	15.5	21750	15.8	2.3–46.0	-
	Carbapenem (imipenem/meropenem) resistance	14274	18.9	16473	18.8	17496	18.1	20517	17.9	22267	18.1	3.5–45.9	↓
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	14118	21.8	16460	21.2	17635	20.5	20425	19.6	22129	18.7	3.3–48.0	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	14117	14.4	16393	12.9	17552	12.6	12880	9.4	14537	8.9	0.0–41.7	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[d]	13022	14.1	15514	14.1	16289	13.5	12041	13.6	13684	12.6	0.0–42.1	↓
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	5389	37.6	5798	36.4	5209	36.9	7507	37.9	10732	39.9	0.0–99.5	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	5294	42.0	5754	41.1	5181	40.9	7372	41.7	10626	43.0	1.5–99.8	-
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[c]	5252	36.3	5711	35.2	5170	36.9	7275	37.0	10399	39.6	2.1–98.8	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[c]	5126	32.1	5607	32.4	4998	33.6	7111	34.0	10172	36.8	0.0–98.5	↑*
S. aureus	MRSA[e]	57396	18.4	63837	17.8	65604	17.2	72976	16.7	78633	15.8	0.9–42.9	↓*
S. pneumoniae	Penicillin non-wild-type[f]	13219	14.0	14498	14.0	14568	13.2	8076	15.5	8465	16.3	3.6–35.7	↑*
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	13302	17.2	14753	16.6	15069	15.9	8407	16.8	8758	18.3	0.0–36.0	-
	Combined penicillin non-wild-type and resistance to macrolides[f]	12669	9.1	14016	8.6	14102	8.0	7782	8.9	8141	9.9	0.0–28.0	-
E. faecalis	High-level gentamicin resistance	13930	29.7	15343	27.1	13577	25.3	14316	29.0	16301	29.0	6.7–55.2	-
E. faecium	Vancomycin resistance	11981	13.4	13346	16.2	14095	17.7	18349	16.8	22315	17.2	0.0–66.4	↑*

[a] Lowest and highest national AMR percentage among reporting EU/EEA countries (n=29).
[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend.
[c] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[d] The aminoglycoside group includes only tobramycin from 2020 onwards.
[e] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[f] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by local laboratories as susceptible, increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

reporting, as the increase was confirmed among the laboratories that continuously reported data each year during the period 2017–2021 (n=666). In 2021, the average number of reported cases resistant to each of the three antimicrobial groups presented in this report (carbapenems, fluoroquinolones and aminoglycosides) was more than double (+121%) the average for 2018–2019. In addition, the population-weighted mean AMR percentage had increased by more than 20% for each of these groups among the continuously reporting laboratories [11]. The largest increases in the number of cases and AMR percentages of *Acinetobacter* spp. were reported by countries that already had high AMR percentages in their reported *Acinetobacter* spp. cases prior to 2020. At country level, among all reporting laboratories in 2021, the percentage of *Acinetobacter* spp. cases resistant to all three antimicrobial groups ranged from 0.0 to 98.5% (Table 7a). Together, these findings imply that the situation with *Acinetobacter* spp. in the EU/EEA has deteriorated for the second year in a row. *Acinetobacter* spp. in healthcare is problematic since it can persist in the healthcare environment for long periods and is notoriously difficult to eradicate once established. AMR reduces options for treatment of infections. Options for national preparedness and response include ensuring that hospitals can perform timely screening, laboratory reporting and pre-emptive isolation of high-risk patients; good IPC; rigorous environmental cleaning and disinfection and antimicrobial stewardship programmes.

For *K. pneumoniae*, the percentage of cases resistant to carbapenems continued to increase, and this was also observed among laboratories that continuously reported data from 2017 to 2021 (Table 7b). In these laboratories, the percentage remained unchanged from 2017 to 2018, before increasing by +8% between 2018 and 2019 [11]. Then, in 2020, the percentage of carbapenem-resistant *K. pneumoniae* cases reported by these laboratories increased by a further +31%, and in 2021 by another +20% [11]. The percentages of carbapenem-resistant cases varied widely by country (0.0–73.7%) (Table 7a), implying that there are still further opportunities to counter this AMR threat.

In 2021, the population-weighted mean percentage of vancomycin resistance in *E. faecium* reached 17.2%, and the rapid and continuous increase in the percentage of vancomycin resistance in *E. faecium* in the EU/EEA is a cause for concern.

For *S. pneumoniae*, there was a drop in the number of reported cases in the EU/EEA in 2020 compared to 2019. However, this number remained relatively stable in 2021. In this context, the percentage of penicillin non-wild-type cases increased from 14.0% in 2017 to 16.3% in 2021 (Table 7b).

Otherwise, during the period 2017–2021, for the EU/EEA, most of the bacterial species–antimicrobial combinations in this report showed either a significantly decreasing trend or no significant trend in the population-weighted mean AMR percentage – in particular *E. coli* (other than carbapenem-resistant), *K. pneumoniae* (other than carbapenem-resistant), *P. aeruginosa* and MRSA (Table 7b). Nevertheless, these pathogens remain important in the EU/EEA, with high AMR percentages. As expected, AMR percentages were generally higher for *K. pneumoniae* and *P. aeruginosa* than for *E. coli* for each reported antimicrobial group/agent (Table 7b).

The reported AMR percentages varied widely among countries for several bacterial species–antimicrobial group combinations, often with a north-to-south and west-to-east gradient. In general, the lowest AMR percentages were reported by countries in the north of the EU/EEA, and the highest AMR percentages by countries in the south and east of the EU/EEA [12].

Bacterial species-specific results

Escherichia coli

Epidemiology

For 2021, 29 EU/EEA countries reported 144 260 isolates of *E. coli*. Of these, 108 730 (75.4%) isolates had AST results for aminopenicillins, 143 180 (99.3%) for third-generation cephalosporins, 143 253 (99.3%) for fluoroquinolones, 139 435 (96.7%) for aminoglycosides and 137 526 (95.3%) for carbapenems (Table 7a).

At EU/EEA level, more than half (52.3%) of the *E. coli* isolates reported to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (aminopenicillins, fluoroquinolones, third-generation cephalosporins, aminoglycosides and carbapenems) (Table 8). In 2021, the highest EU/EEA population-weighted mean resistance percentage was reported for aminopenicillins (53.1%), followed by fluoroquinolones (21.9%), third-generation cephalosporins (13.8%) and aminoglycosides (9.6%). Resistance to carbapenems remained rare (0.2%) (Table 7a).

Between 2017 and 2021, there was a significantly increasing trend in the EU/EEA population-weighted mean percentage for carbapenem resistance, while the EU/EEA trends for aminopenicillin resistance, third-generation cephalosporin resistance, fluoroquinolone resistance and aminoglycoside resistance decreased significantly during the same period. When restricting the analysis to include only laboratories that continuously reported data for all five years, all trends remained significant (Table 7b). Larger annual decreases in EU/EEA-level resistance percentages were seen in 2021 than in the period 2017–2020 for fluoroquinolones (-1.9%), aminoglycosides (-1.3%), and third-generation cephalosporins (–1.1%) (Table 7b).

Resistance to multiple antimicrobial groups was common. Among the resistant phenotypes, resistance to aminopenicillins, both as single resistance or in combination with other antimicrobial groups, was the most common at EU/EEA level (Table 8). In 2021, the percentage of combined resistance, measured as resistance to third-generation cephalosporins,

Table 8 ***Escherichia coli.*** **Total number of invasive isolates tested (n = 99 038)[a] and AMR percentage (%) per phenotype, EU/EEA, 2021**

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**47 225**	**47.7**
Single resistance (to indicated antimicrobial group)		
Total (all single resistance)	**32 659**	**33.0**
Aminopenicillins	29 751	30.0
Fluoroquinolones	2516	2.5
Other antimicrobial groups	392	0.4
Resistance to two antimicrobial groups		
Total (all two-group combinations)	**9564**	**9.7**
Aminopenicillins + fluoroquinolones	5335	5.4
Aminopenicillins + third-generation cephalosporins	2454	2.5
Aminopenicillins + aminoglycosides	1639	1.7
Other antimicrobial group combinations	136	0.1
Resistance to three antimicrobial groups		
Total (all three-group combinations)	**6180**	**6.2**
Aminopenicillins + third-generation cephalosporins + fluoroquinolones	4212	4.3
Aminopenicillins + fluoroquinolones + aminoglycosides	1541	1.6
Other antimicrobial group combinations	427	0.4
Resistance to four antimicrobial groups		
Total (all four-group combinations)	**3386**	**3.4**
Aminopenicillins + third-generation cephalosporins + fluoroquinolones + aminoglycosides	3365	3.4
Other antimicrobial group combinations	21	‹0.1
Resistance to five antimicrobial groups		
Aminopenicillins + third-generation cephalosporins + fluoroquinolones + aminoglycosides + carbapenems	24	‹0.1

[a] Only isolates with complete susceptibility information for aminopenicillins (amoxicillin or ampicillin), third-generation cephalosporins (cefotaxime, ceftriaxone or ceftazidime), carbapenems (imipenem or meropenem), fluoroquinolones (ciprofloxacin, levofloxacin or ofloxacin) and aminoglycosides (gentamicin or tobramycin) were included in the analysis. This represented 68.7% (99 038/144 260) of all reported *E. coli* isolates.
[b] Only AMR combinations › 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.

Fig. 11 ***Escherichia coli.*** **Percentage of invasive isolates resistant to fluoroquinolones (ciprofloxacin/levofloxacin/ofloxacin), by country, EU/EEA, 2021**

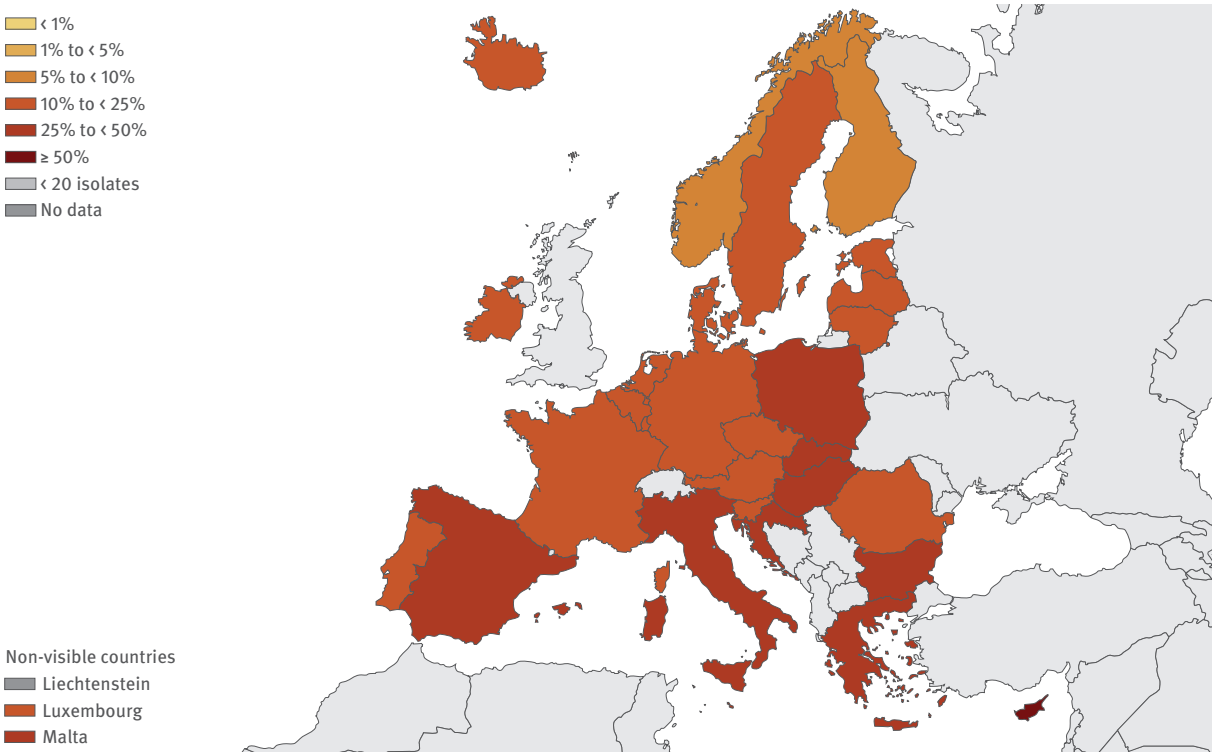

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Fig. 12 ***Escherichia coli.*** **Percentage of invasive isolates resistant to third-generation cephalosporins (cefotaxime/ceftriaxone/ceftazidime), by country, EU/EEA, 2021**

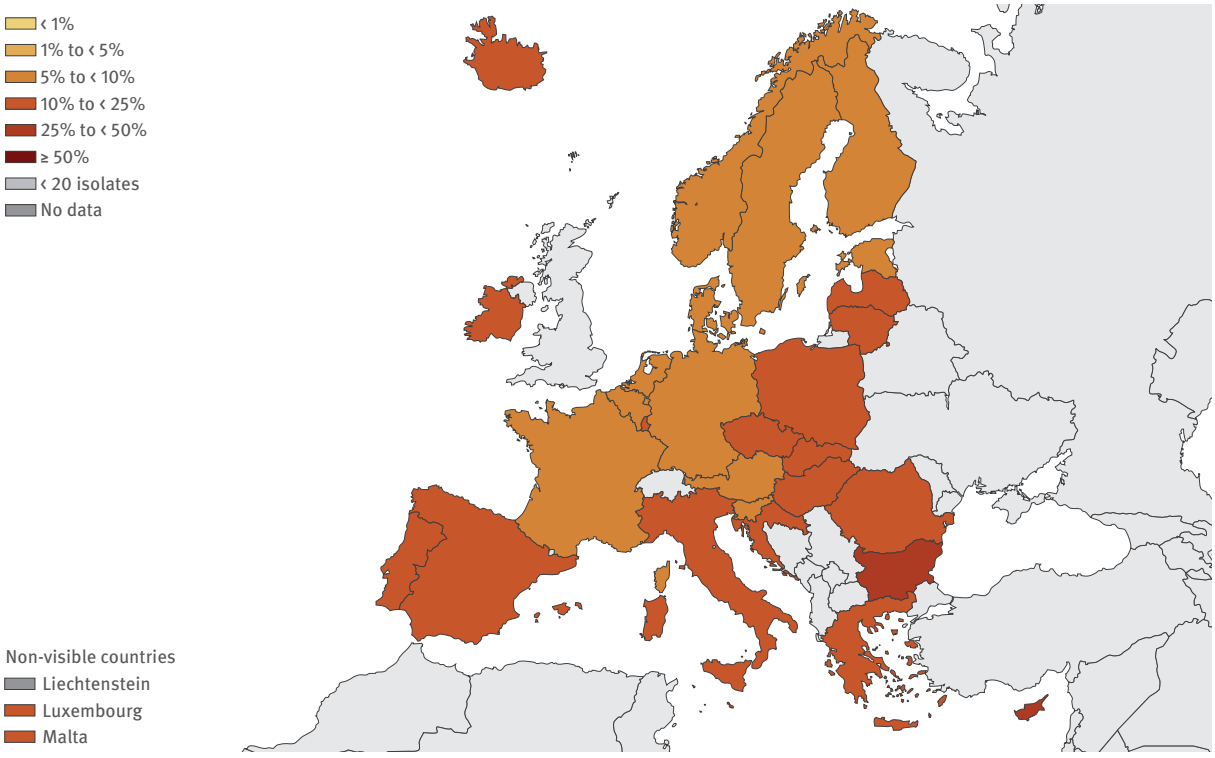

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Fig. 13 ***Escherichia coli.*** **Percentage of invasive isolates resistant to carbapenems (imipenem/meropenem), by country, EU/EEA, 2021**

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fluoroquinolones and aminoglycosides, was 5.1% (EU/EEA population-weighted mean) and this showed a statistically significant decreasing trend during the period 2017–2021 (Table 7b).

With the exception of carbapenem resistance, which remained low in all countries, large inter-country variations were noted for all the antimicrobial groups under surveillance (Table 7a), with generally higher AMR percentages reported from southern and eastern Europe than from northern Europe (Fig. 11–13).

Discussion

E. coli is a major cause of bloodstream infection in Europe, and prompt access to effective antimicrobial treatment is essential to reduce the health-related and economic burden caused by *E. coli* infection. In ECDC's study of the EU/EEA health burden of AMR for the period 2016–2020, the largest burden of disease was caused by infections with third-generation cephalosporin-resistant *E. coli*, both in terms of the number of cases and the number of attributable deaths [13]. As antimicrobial-resistant *E. coli* infections commonly occur in the community, interventions to reduce the burden of infection should not be restricted to hospital settings, but should also target primary and community care.

Time-series analyses of EU/EEA population-weighted means for third-generation cephalosporin resistance and fluoroquinolone resistance in *E. coli* reported to EARS-Net for the years 2002–2018 have shown that while AMR percentages increased substantially during the period, the increase was most prominent until around 2012. It then became less pronounced [14]. A significantly declining EU/EEA trend was noted for the five-year period presented in this report (2017–2021). However, it should be noted that the 2021 EARS-Net EQA indicated that decreased susceptibility towards fluroquinolones is under-reported by EARS-Net laboratories [15]. Percentages of AMR reported for 2021 nevertheless remain at a high level, highlighting the need for further efforts to improve antimicrobial stewardship and IPC.

Use of broad-spectrum antimicrobials is a known risk factor for the colonisation and spread of antimicrobial-resistant Enterobacterales, including *E. coli*. Associations between national AMR percentages in *E. coli* and national antimicrobial consumption rates have been reported [16]. Although the latest data from ESAC-Net show a considerable decrease in antimicrobial consumption in 2020 and 2021 compared to previous years [3], a less uniform pattern is reflected for AMR percentages at EU/EEA level. The latest data from ESAC-Net also show that large inter-country variations in the use of broad-spectrum antimicrobials remain [3], indicating a need for increased focus on antimicrobial stewardship and highlighting the potential for further reductions in antimicrobial consumption.

As high AMR levels have been reported in *E. coli* isolates from food-producing animals in Europe, including the rare occurrence of isolates with carbapenemase production [17], ensuring cross-sectoral collaboration between the human, veterinary and food-production sectors is essential in a 'One-Health' approach, which addresses AMR in both humans and food-producing animals. ECDC is working closely with the European Food Safety Authority and the European Medicines Agency to better understand the interrelationships between antimicrobial use and AMR in humans and animals across Europe, and produced the third joint inter-agency report on integrated analysis of antimicrobial agent consumption and occurrence of AMR in bacteria from humans and food-producing animals in 2021 [16].

Carbapenem-resistant isolates remained rare among the invasive *E. coli* isolates included in EARS-Net, however there was a small but significant increase in the EU/EEA population-weighted mean between 2017 and 2021. Although the interpretation of the increase in 2021 should take into account that the 2021 EARS-Net EQA indicated that decreased carbapenem susceptibility may be over-reported in EARS-Net [15], a further increase in serious infections caused by carbapenem-resistant *E. coli* would have severe consequences on the burden of AMR in the EU/EEA. Carbapenem-resistant Enterobacterales (CRE) infections are associated with high mortality, primarily due to delays in the administration of effective treatment and the limited availability of treatment options. The 2019 update of ECDC's rapid risk assessment on CRE highlights the need for high standards in IPC, combined with adequate microbiological capacity to detect and prevent further spread [18].

Carbapenem resistance is most often mediated by a range of carbapenemases and there are carbapenemase-producing isolates that test susceptible to meropenem and/or imipenem, based on clinical breakpoints. One example is OXA-244-producing *E. coli* which, in routine clinical microbiology laboratories, may only be classified as extended-spectrum beta-lactamase-producing rather than carbapenemase-producing *E. coli*, unless specifically tested for OXA-48-like carbapenemases. An ECDC risk assessment on OXA-244-producing *E. coli* [19] indicated a pan-European problem, with a high risk of OXA-244-producing *E. coli* spreading further in the EU/EEA, given the rapid and simultaneous increase in multiple countries between 2016 and 2019. There is a risk that spread of OXA-244-producing *E. coli* in the community may further contribute to the loss of carbapenems as options for treatment of multidrug-resistant *E. coli* infections. This highlights the need to further investigate the sources and routes of transmission for carbapenemase-producing *E. coli*.

To address the need and to complement the phenotypic-based surveillance data available from EARS-Net, the periodic carbapenem- and/or colistin-resistant Enterobacterales (CCRE) surveys are now incorporated into a new network - the European Antimicrobial Resistance Genes Surveillance Network (EURGen-Net) [20]. The latest survey results will provide information on the prevalence and distribution of carbapenemases and contribute to a better understanding

of the epidemiology of CRE in Europe and risk factors associated with CRE infection and colonisation. ECDC is also able, to a limited extent, to provide Member States with access to whole-genome sequencing services, primarily for investigating potential multi-country outbreaks. By way of example, these services were provided for a combined clonal and plasmid-mediated outbreak of carbapenemase-producing Enterobacterales in Lithuania during the period 2019–2020 [21].

Klebsiella pneumoniae

Epidemiology

For 2021, 29 EU/EEA countries reported 43 617 isolates of *K. pneumoniae*. Of these, 43 261 (99.2%) isolates had AST results for third-generation cephalosporins, 43 136 (98.9%) for fluoroquinolones, 42 181 (96.7%) for aminoglycosides and 42 007 (96.3%) for carbapenems (Table 7a).

At EU/EEA level, more than a third (38.4%) of the *K. pneumoniae* isolates reported to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (fluoroquinolones, third-generation cephalosporins, aminoglycosides and carbapenems) (Table 9). In 2021, the highest EU/EEA population-weighted mean resistance percentage was reported for third-generation cephalosporins (34.3%), followed by fluoroquinolones (33.6%), aminoglycosides (23.7%) and carbapenems (11.7%) (Table 7a).

Between 2017 and 2021, there was a significantly increasing trend in the EU/EEA population-weighted mean percentage for carbapenem resistance, while the EU/EEA trend for fluoroquinolones and aminoglycoside resistance decreased significantly during the same period. When the analysis was restricted to include only laboratories that continuously reported data, the EU/EEA trends for carbapenems and aminoglycosides remained significant (Table 7b).

It is of interest to note that the annual change in resistance percentage at EU/EEA level indicated a relatively large increase in 2021 (1.7%) for carbapenems compared with the period 2017–2020 (Table 7b). The rate of increase, relative to the previous year, also increased each year in the period 2017–2021, by +5%, +6%, +11% and +17%, respectively. Among continuously reporting laboratories the percentage remained unchanged from 2017 to 2018, and increased by +8% from 2018 to 2019. Then, in 2020, the percentage of carbapenem-resistant *K. pneumoniae* cases reported by these laboratories increased by another +31%, and in 2021 by another +20% [11].

Single resistance was less commonly reported than resistance to two, three or four antimicrobial groups, with the most common AMR phenotype being combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides (Table 9). The EU/EEA population-weighted mean for combined resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides was 21.2% in 2021 and showed a statistically significant decreasing trend during the period 2017–2021 (Table 7b), although the trend did not remain when the analysis was restricted to laboratories that continuously reported data.

Table 9 *Klebsiella pneumoniae*. Total number of invasive isolates tested (n = 40 160)[a] and AMR percentage (%) per phenotype, EU/EEA, 2021

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**24 733**	**61.6**
Single resistance (to indicated antimicrobial group)		
Total (all single resistance)	**3 035**	**7.6**
Third-generation cephalosporins	1 436	3.6
Fluoroquinolones	1 418	3.5
Other antimicrobial groups	181	0.5
Resistance to two antimicrobial groups		
Total (all two-group combinations)	**3 239**	**8.1**
Third-generation cephalosporins + fluoroquinolones	2 368	5.9
Third-generation cephalosporins + aminoglycosides	480	1.2
Other antimicrobial group combinations	391	1.0
Resistance to three antimicrobial groups		
Total (all three-group combinations)	**5 963**	**14.8**
Third-generation cephalosporins + fluoroquinolones + aminoglycosides	4 659	11.6
Third-generation cephalosporins + fluoroquinolones + carbapenems	1 228	3.1
Other antimicrobial group combinations	76	0.2
Resistance to four antimicrobial groups		
Third-generation cephalosporins + fluoroquinolones + aminoglycosides + carbapenems	3 190	7.9

[a] Only isolates with complete susceptibility information for third-generation cephalosporins (cefotaxime, ceftriaxone or ceftazidime), carbapenems (imipenem or meropenem), fluoroquinolones (ciprofloxacin, levofloxacin or ofloxacin) and aminoglycosides (gentamicin or tobramycin) were included in the analysis. This represented 92.1% (40 160/43 617) of all reported *K. pneumoniae* isolates.
[b] Only AMR combinations > 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.

Large inter-country variations were noted for all antimicrobial groups under surveillance (Table 7a), with generally higher AMR percentages reported from southern and eastern Europe than from northern Europe (Fig. 14 and 15). Nine countries reported carbapenem resistance percentages above 10.0% for *K. pneumoniae* [12]. The countries reporting the highest percentages of carbapenem resistance in *K. pneumoniae* were also among those reporting the highest AMR percentages for the other antimicrobial groups.

Discussion

The AMR situation with *K. pneumoniae* in the EU/EEA remains problematic. ECDC's study of the EU/EEA health burden of AMR for the period 2016–2020 showed that the largest burden of disease was caused by infections with third-generation cephalosporin-resistant *E. coli*, followed by MRSA and third-generation cephalosporin-resistant *K. pneumoniae*. Infections with these three antibiotic-resistant bacteria resulted in the largest health impact, generating 58.2% of the total burden as measured in disability-adjusted life years (DALYs) [13].

In addition, although the 2021 EARS-Net EQA indicated that decreased carbapenem susceptibility in *K. pneumoniae* was probably over-reported in 2021 [15], there was nevertheless a significantly increasing trend in the EU/EEA population-weighted mean percentages for carbapenem resistance during the period 2017 to 2021, as well as a proportionally larger increase from 2020 to 2021 compared to the annual change in the previous years covered by this report. Carbapenem resistance was almost always combined with resistance to several other key antimicrobial groups, leading to a severely limited range of treatment options for serious infections caused by this type of bacteria. ECDC's studies of the AMR health burden found that even though the level of carbapenem-resistant *K. pneumoniae* was relatively low, the impact of AMR on the EU/EEA health burden is heavy because of the high level of attributable mortality of these infections [13,22]. In 2020, the number of deaths attributable to carbapenem-resistant *K. pneumoniae* in 2020 was estimated to be 4 076 [13]. This underlines the need for continuous close monitoring and greater efforts to respond efficiently to this public health threat.

The highest percentages of carbapenem resistance were observed in south and south-eastern Europe, similar to the distribution of carbapenemase-producing Enterobacterales (CRE) reflected in a survey conducted by EURGen-Net [23]. Results from EURGen-Net also show that in several EU/EEA countries the situation deteriorated between 2010 and 2018 with regard to the spread of carbapenemase-producing Enterobacterales [23]. Numerous reports on outbreaks with varying potential for, or recorded cross-border spread of CRE demonstrate the transmission potential in the healthcare systems of EU/EEA countries [24–26]. Outbreaks and clusters in EU/EEA countries also highlight the importance of detecting CRE early in settings with low incidence, due to their high transmissibility [24–28].

CRE can be resistant to carbapenems as a result of a variety of mechanisms, but most frequently it is through production of carbapenemase enzymes. It is not possible to assess the overall presence and spread of carbapenemase-producing Enterobacterales through the data available from EARS-Net, as some carbapenemases do not confer a fully carbapenem-resistant phenotype. One example is the OXA-48-like carbapenemase enzymes, which present a particular problem for laboratory detection because of their weak capacity to hydrolyse carbapenems [24].

Recent outbreaks of carbapenemase (NDM-1 and OXA-48)-producing and colistin-resistant *K. pneumoniae* have highlighted the concomitant increase in virulence, transmissibility and AMR among certain *K. pneumoniae* strains. These strains pose a considerably higher risk to human health than the *K. pneumoniae* strains that previously circulated. A 2021 rapid risk assessment by ECDC raised the issue of emerging hypervirulent *K. pneumoniae* ST23 carrying carbapenemase genes [29]. The limited information available so far indicates that very few cases and clusters have been reported in the EU/EEA. Nevertheless, early detection of such strains, and close cooperation between clinicians and public health services is crucial to prevent them spreading among the patient population in the EU/EEA.

There is a need for increased capacity in the EU/EEA to support outbreak investigations and surveillance with real-time whole genome sequencing in order to identify high-risk clones and implement enhanced control measures to avoid further spread [27–28]. One initiative to address this need is the CCRE surveys (part of EURGen-Net) that will provide updated and more detailed information on the distribution of carbapenemase-producing *K. pneumoniae* in Europe [20].

As highlighted in the 2019 update of ECDC's rapid risk assessment on CRE, options for action include timely and appropriate diagnosis, high standards of IPC and antimicrobial stewardship [18]. Many EU/EEA countries have developed and implemented recommendations and guidance documents on multidrug-resistant Enterobacterales and/or CRE [30], indicating a trend towards nationally coordinated responses to this public health threat. In 2017, to support countries ECDC published a guidance document on how to prevent the entry and spread of CRE into healthcare settings. The guidance outlines evidence-based best practices for the prevention of CRE, including measures for intervention that can be adopted or adapted to local needs, depending on the availability of financial and structural resources [31].

Resistance to newly released antimicrobials has turned out to be a challenge for the optimal treatment of infections with CRE that are resistant to these new antimicrobials [32]. This highlights the need to also monitor for resistance to new antimicrobials. In addition, WHO sees a critical need for research and development of new antibiotics targeting third-generation cephalosporin-resistant and carbapenem-resistant Enterobacterales, including *K. pneumoniae* and *E. coli* [33].

Fig. 14 ***Klebsiella pneumoniae*. Percentage of invasive isolates resistant to third-generation cephalosporins (cefotaxime/ceftriaxone/ceftazidime), by country, EU/EEA, 2021**

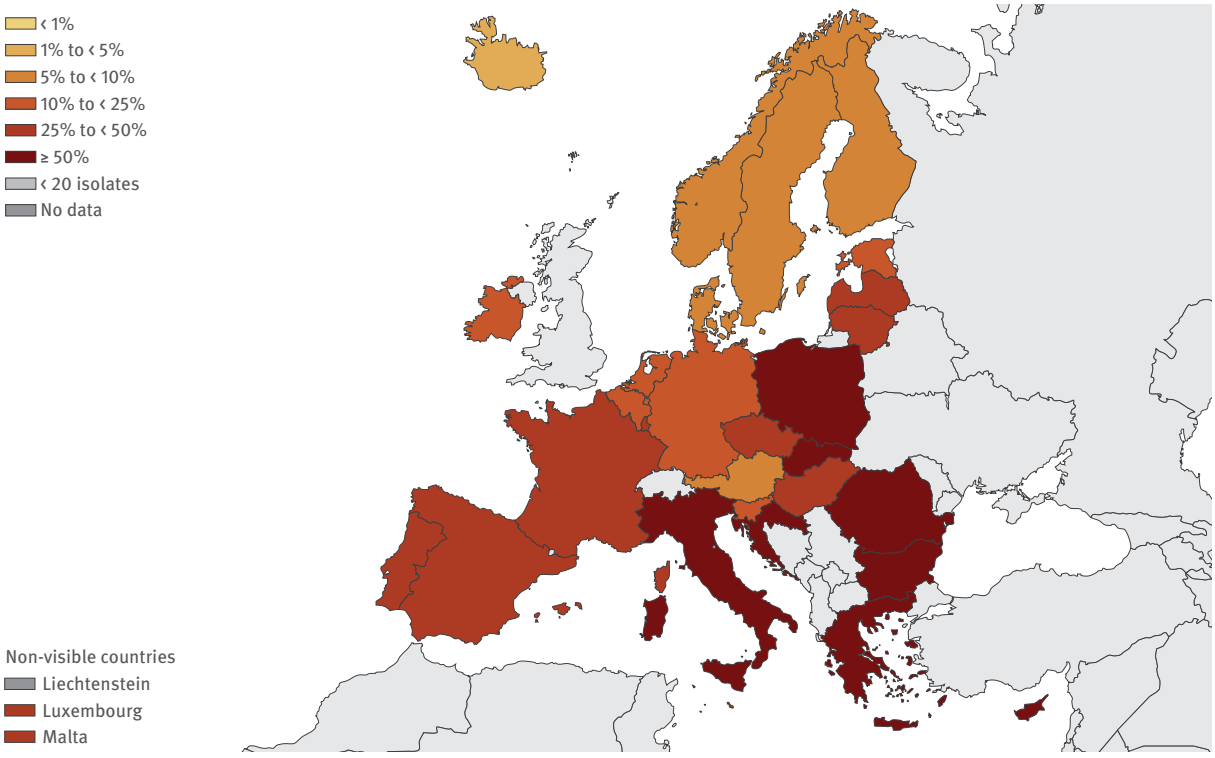

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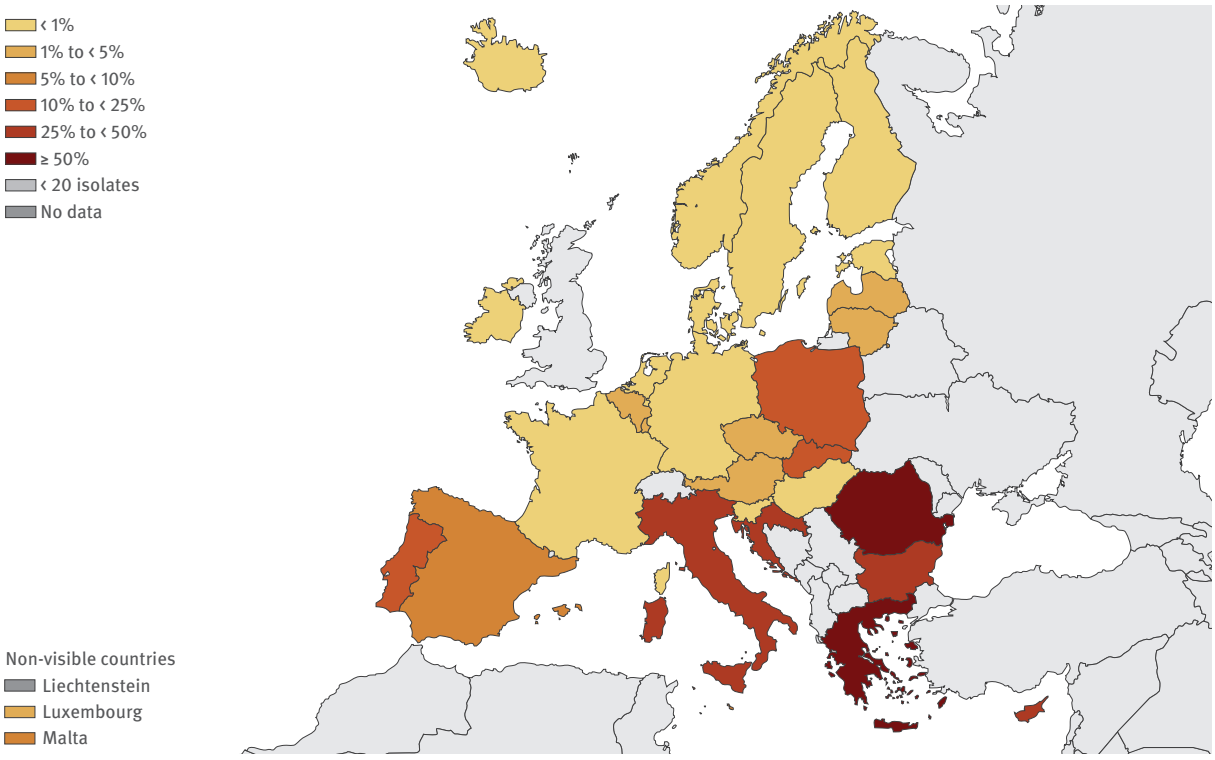
Fig. 15 ***Klebsiella pneumoniae*. Percentage of invasive isolates resistant to carbapenems (imipenem/meropenem), by country, EU/EEA, 2021**



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Pseudomonas aeruginosa

Epidemiology

For 2021, 29 EU/EEA countries reported 22 479 isolates of *P. aeruginosa*. Of these, 21 419 (95.3%) isolates had AST results for piperacillin-tazobactam, 21 750 (96.8%) for ceftazidime, 22 129 (98.4%) for fluoroquinolones, 14 537 (64.7%) for aminoglycosides and 22 267 (99.1%) for carbapenems (Table 7a).

In the EU/EEA, 31.0% of the *P. aeruginosa* isolates reported to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (piperacillin-tazobactam, fluoroquinolones, ceftazidime, aminoglycosides and carbapenems) (Table 10). The highest EU/EEA population-weighted mean resistance percentage in 2021 was reported for fluoroquinolones (18.7%) and piperacillin-tazobactam (18.7%), followed by carbapenems (18.1%), ceftazidime (15.8%) and aminoglycosides (8.9%) (Table 7a).

Between 2017 and 2021, EU/EEA trends decreased significantly for all but two antimicrobial groups under surveillance (piperacillin-tazobactam and ceftazidime). When restricting the analysis to include only laboratories that continuously reported data for all five years, the trends for fluoroquinolone and aminoglycoside resistance remained statistically significant while the carbapenem resistance did not (Table 7b). For *P. aeruginosa* and aminoglycosides there was a considerable change in the analysis as of 2020 that could affect the results when compared with the period 2017–2019 (Table 7b).

Resistance to two or more antimicrobial groups was common: found in 17.9% of all tested isolates (Table 10). Between 2017 and 2021, the EU/EEA population-weighted mean percentage of combined resistance, defined as resistance to at least three of the antimicrobial groups under surveillance, significantly decreased from 14.1% to 12.6% (Table 7b). Large inter-country variations were noted for all antimicrobial groups (Table 7a), with reported AMR percentages generally higher from southern and eastern Europe than northern Europe (Fig. 16).

Discussion

EARS-Net data showed that at EU/EEA level, trends in resistance decreased significantly for *P. aeruginosa* for several of the antimicrobial groups under surveillance during the period 2017 to 2021. Nevertheless, high AMR percentages and combined AMR persisted in many countries, especially in the eastern and south-eastern parts of Europe. As *P. aeruginosa* is intrinsically resistant to many antimicrobial agents, additional acquired resistance is further complicating the treatment of *P. aeruginosa* infections.

Table 10 *Pseudomonas aeruginosa*. Total number of invasive isolates tested (n = 13 689)[a] and AMR percentage (%) per phenotype, EU/EEA, 2021

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**9447**	**69.0**
Single resistance (to indicated antimicrobial group)		
Total (all single resistance types)	**1796**	**13.1**
Carbapenems	769	5.6
Fluoroquinolones	670	4.9
Piperacillin-tazobactam	211	1.5
Other antimicrobial groups	146	1.1
Resistance to two antimicrobial groups		
Total (all two-group combinations)	**1031**	**7.5**
Piperacillin-tazobactam + ceftazidime	535	3.9
Fluoroquinolones + carbapenems	241	1.8
Other antimicrobial group combinations	255	1.9
Resistance to three antimicrobial groups		
Total (all three-group combinations)	**554**	**4.0**
Piperacillin-tazobactam + ceftazidime + carbapenems	181	1.3
Piperacillin-tazobactam + ceftazidime + fluoroquinolones	168	1.2
Other antimicrobial group combinations	205	1.5
Resistance to four antimicrobial groups		
Total (all four-group combinations)	**377**	**2.8**
Piperacillin-tazobactam + fluoroquinolones + ceftazidime + carbapenems	207	1.5
Other antimicrobial group combinations	170	1.2
Resistance to five antimicrobial groups		
Piperacillin-tazobactam + fluoroquinolones + ceftazidime + aminoglycosides + carbapenems	484	3.5

[a] Only isolates with complete susceptibility information for piperacillin-tazobactam, ceftazidime, carbapenems (imipenem or meropenem), fluoroquinolones (ciprofloxacin or levofloxacin) and aminoglycosides (tobramycin) were included in the analysis. This represented 60.9% (13 689/22 479) of all reported *P. aeruginosa* isolates.
[b] Only AMR combinations > 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.

The public health implications of AMR in *P. aeruginosa* should not be ignored, as *P. aeruginosa* remains one of the major causes of healthcare-associated infection in Europe [34]. In addition, a recent ECDC report based on EARS-Net data estimated that in 2020 there were 67 638 infections with carbapenem-resistant *P. aeruginosa* and 3 210 deaths attributable to the same bacterial species antimicrobial group combination [13].

Trends in *P. aeruginosa* cases might have been expected to follow those observed for *Acinetobacter* spp. in this report, given that it is also often linked to environmental sources and the rate of ventilator use among hospitalised COVID-19. However the trends for *P. aeruginosa* cases remained relatively unchanged. Pandemic-related factors may partially explain this – for example, changes in the lengths of hospital stays, and greater shielding of patients at risk of both COVID-19 and *P. aeruginosa* infection, such as cystic fibrosis patients. Nevertheless, ECDC does not have incidence surveillance for pneumonias and lower respiratory tract infections, which, for *P. aeruginosa*, are the site of three times as many healthcare-associated infections [35].

An analysis based on 2016 EARS-Net data highlighted that countries reporting high percentages of *P. aeruginosa* and *Acinetobacter* spp. bloodstream infections among all reported bloodstream infections were also those where the percentage of isolates with acquired AMR in gram-negative bacteria was generally highest [36]. This finding is probably attributable to shared risk factors, such as a high consumption of broad-spectrum antimicrobials and varying IPC practices in healthcare [37]. Addressing these factors and implementing high standards of IPC in healthcare across these countries would probably have a positive impact, both on the burden of infections caused by bacteria with high levels of intrinsic AMR, such as *P. aeruginosa* and *Acinetobacter* spp., and most likely also on bacteria with acquired AMR.

At the global level, WHO has listed carbapenem-resistant *P. aeruginosa* as a pathogen of critical priority that requires research and the development of new antibiotics [33].

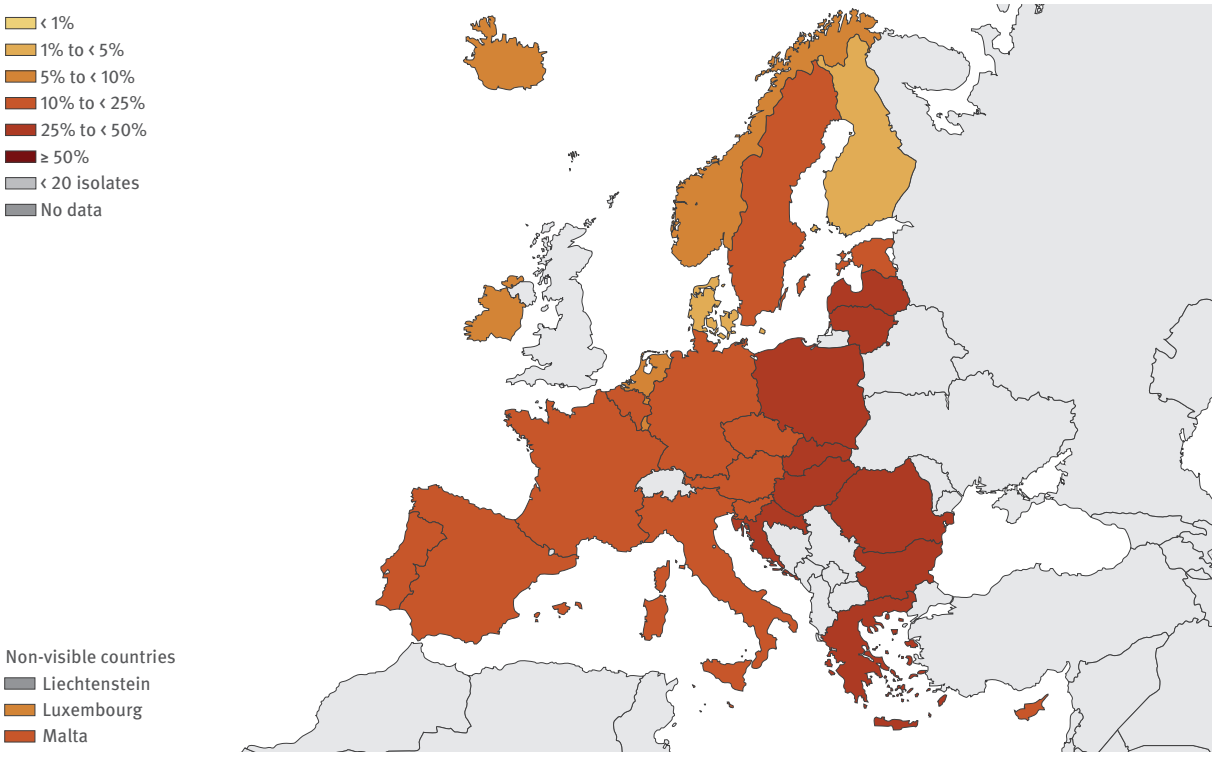
Acinetobacter species

Epidemiology

For 2021, 29 EU/EEA countries reported 10 885 isolates of *Acinetobacter* spp., with four EU/EEA countries each reporting fewer than 30 isolates. Compared to the number of reported isolates for 2019 (n=5 375) the number has more than doubled. Of the isolates reported for 2021, 10 626 (97.6%) isolates had AST results for fluoroquinolones, 10 399 (95.5%) for aminoglycosides and 10 732 (98.6%) for carbapenems (Table 7a).

Almost three quarters (74.5%) of the *Acinetobacter* spp. isolates reported by EU/EEA countries to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (fluoroquinolones, aminoglycosides and carbapenems) (Table 11). The highest

Fig. 16 *Pseudomonas aeruginosa*. Percentage of invasive isolates with resistance to carbapenems (imipenem/meropenem), by country, EU/EEA, 2021



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EU/EEA population-weighted mean AMR percentage in 2021 was reported for fluoroquinolones (43.0%), followed by carbapenems (39.9%) and aminoglycosides (39.6%) (Table 7a).

Between 2017 and 2021, a significant increasing trend was detected for carbapenem and aminoglycoside resistance in the EU/EEA (Table 7b). In 2021, relatively large annual increases in resistance percentage were also seen for aminoglycosides (2.6%), carbapenems (2.0%), and fluoroquinolones (1.3%) at EU/EEA level compared with the period 2017–2020 (Table 7b).

Among the laboratories that continuously reported data during 2017–2021 (n=666), the increase in the number of antimicrobial-resistant isolates was more pronounced in 2021, compared to the average for 2018 and 2019 (+121% on average, for each of these three groups). In addition, the population-weighted mean AMR percentage among the continuously reporting laboratories increased by more than 20% for each of these groups, with the percentage of isolates resistant to carbapenems reaching 48% in 2021 [11].

Resistance to one or two antimicrobial groups was considerably less common than combined resistance to all three groups under surveillance (Table 11). Between 2017 and 2021, the EU/EEA population-weighted mean percentage for combined resistance to carbapenems, fluoroquinolones and aminoglycosides significantly increased - from 32.1% to 36.8%. When the analysis was restricted to include only laboratories continuously reporting data for all five years, the trend remained statistically significant (Table 7b).

Large inter-country variations were noted for all antimicrobial groups (Table 7a), with higher AMR percentages generally reported from southern and eastern Europe than northern Europe (see country profiles in Chapter 4 and Fig. 17). The largest increases in the number of cases and AMR percentages of *Acinetobacter* spp. were reported by countries that already had high AMR percentages in their reported *Acinetobacter* spp. cases prior to 2020.

Discussion

Of all the bacterial species under surveillance by EARS-Net, *Acinetobacter* spp. used to be the least commonly reported, but as of 2021 this is no longer the case. *Acinetobacter* spp. had by far the largest annual increase in the number of reported isolates in both 2020 and 2021. During the period 2017–2019, the number of isolates was relatively stable (+/-10.0%). A recent publication based on 2017–2021 EARS-Net data showed that a major part of the increase in reported isolates in 2020–2021, during the COVID-19 pandemic years, consisted of carbapenem-resistant infections in ICU patients, in the countries with carbapenem resistance percentages in *Acinetobacter* spp. exceeding 50% in 2018–2019 [38]. This recent development implies that the situation with the *Acinetobacter* spp. in the EU/EEA has deteriorated and indicates the need for reinforced *Acinetobacter* spp. preparedness, and IPC in EU/EEA healthcare facilities. This need for action is further emphasised by the recent ECDC estimate that in 2020 3656 deaths were attributable to carbapenem-resistant *Acinetobacter* spp. [13].

During the period 2020–2022, *Acinetobacter* spp. was often reported as being the most frequent bacterial coinfection for COVID-19 patients in hospitals, and particularly ICUs, in Europe, North America and the Middle East, causing clonal outbreaks, with high case fatality rates often associated with multidrug resistance [39–42]. The reasons for the increased number of *Acinetobacter* spp. infections in many EU/EEA countries warrant further investigation but are probably directly related to changes in healthcare provision due to the pandemic. *Acinetobacter* spp., and multidrug-resistant strains in particular, are notoriously difficult to eradicate from the hospital environment once established, surviving on dry surfaces, readily contaminating healthcare providers' hands, and being spread by asymptomatic carriers [39]. Given the unprecedented patient loads in

Table 11 *Acinetobacter* species. Total number of invasive isolates tested (n = 10 206)[a] and AMR percentage (%) per phenotype, EU/EEA, 2021

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**2604**	**25.5**
Single resistance (to indicated antimicrobial group)		
Total (any single resistance)	**297**	**2.9**
Fluoroquinolones	177	1.7
Other antimicrobial groups	120	1.2
Resistance to two antimicrobial groups		
Total (any two-group combinations)	**505**	**4.9**
Fluoroquinolones + carbapenems	375	3.7
Fluoroquinolones + aminoglycosides	119	1.2
Other antimicrobial group combinations	11	0.1
Resistance to three antimicrobial groups		
Fluoroquinolones + aminoglycosides + carbapenems	6800	66.6

[a] Only isolates with complete susceptibility information for carbapenems (imipenem or meropenem), fluoroquinolones (ciprofloxacin or levofloxacin) and aminoglycosides (gentamicin or tobramycin) were included in the analysis. This represented 93.8% (10 206/10 885) of all reported *Acinetobacter* spp. isolates.
[b] Only AMR combinations > 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.

ICUs in EU/EEA countries during the period 2020–2021, even hospitals that rigorously and conscientiously applied IPC practices may still have had opportunities for IPC breaches sufficient for *Acinetobacter* spp. transmission [43]. This suggests a requirement for *Acinetobacter* spp.-specific control interventions in the affected hospitals [44].

The inter-country range in AMR percentages remains the widest of all pathogens included in EARS-Net. In 2021, the percentage of isolates resistant to at least one of the antimicrobial groups under surveillance (fluoroquinolones, aminoglycosides or carbapenems) ranged between 0.0% and 99.5%, depending on the reporting country. In general, the highest AMR percentages were reported from southern and eastern Europe. The high levels of AMR in these countries are of great concern since the most frequently reported AMR phenotype was combined resistance to all three antimicrobial groups under surveillance, severely limiting options for patient treatment. It should be pointed out that *Acinetobacter* spp. are intrinsically resistant to many antimicrobial agents, and hence additional acquired AMR is further complicating treatment of *Acinetobacter* spp. infections.

ECDC's risk assessment on carbapenem-resistant *Acinetobacter baumannii* in healthcare settings highlights the need for increased efforts to face this significant threat to patients and healthcare systems in all EU/EEA countries. The document outlines options to reduce risks through clinical management; prevention of transmission in hospitals and other healthcare settings; prevention of cross-border transmission and improvement in the preparedness of EU/EEA countries. Options for response presented in the risk assessment include timely laboratory reporting, screening and pre-emptive isolation of high-risk patients, good IPC, rigorous environmental cleaning and disinfection, and antimicrobial stewardship programmes [44].

WHO has listed carbapenem-resistant *A. baumannii* as a pathogen of critical priority in its global priority list of antibiotic-resistant bacteria requiring research and the development of new antibiotics [33].

Staphylococcus aureus

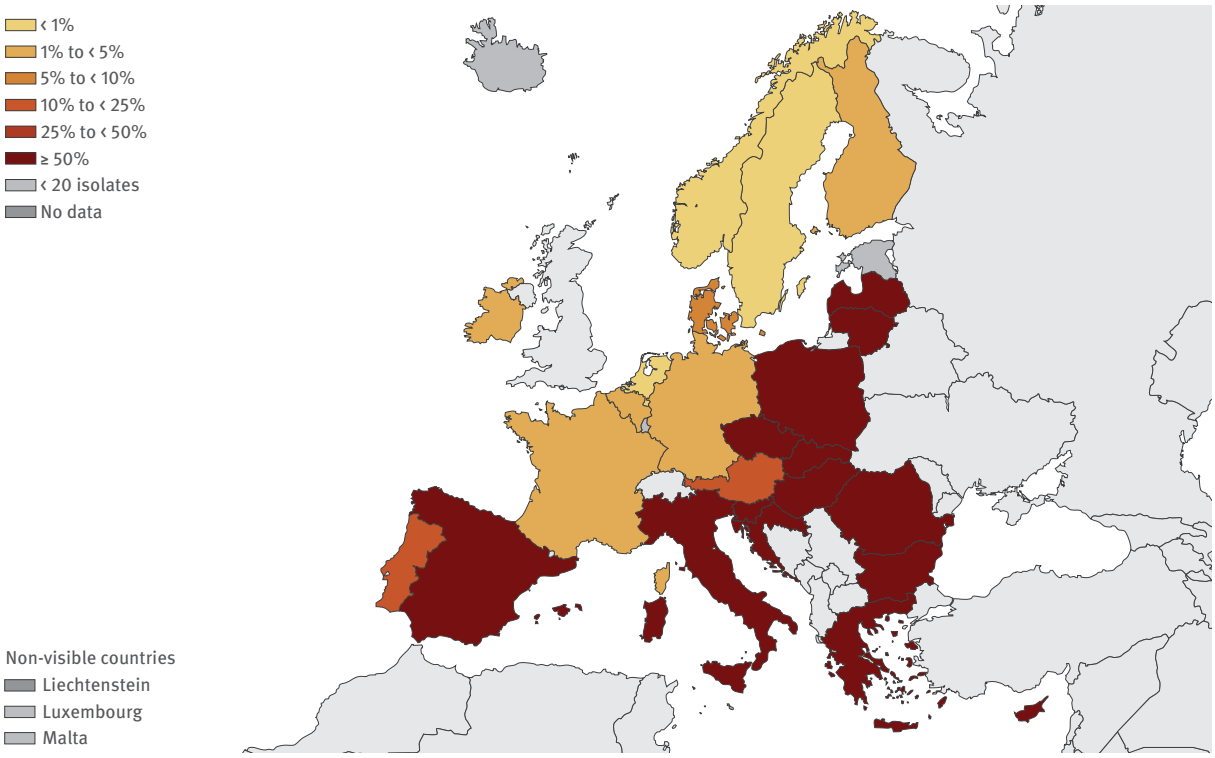
Epidemiology

For 2021, 29 EU/EEA countries reported 81163 isolates of *S. aureus*. Of these, 78633 (96.9%) isolates had AST results or molecular confirmation test results available to determine MRSA (Table 7a).

A little less than one fifth (17.2%) of the *S. aureus* isolates reported by EU/EEA countries to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (meticillin/MRSA, fluoroquinolones and rifampicin) (Table 12).

The EU/EEA population-weighted mean MRSA percentage was 15.8% in 2021. This denotes a significantly decreasing trend for the period 2017–2021, from 18.4% to 15.8%, a trend that remained statistically significant

Fig. 17 *Acinetobacter* species. Percentage of invasive isolates with resistance to carbapenems (imipenem/meropenem), by country, EU/EEA, 2021



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when the analysis was restricted to include only laboratories that continuously reported data for all five years (Table 7b).

With MRSA, combined resistance to another antimicrobial group was common. The most common AMR combination was MRSA and resistance to fluoroquinolones (Table 12).

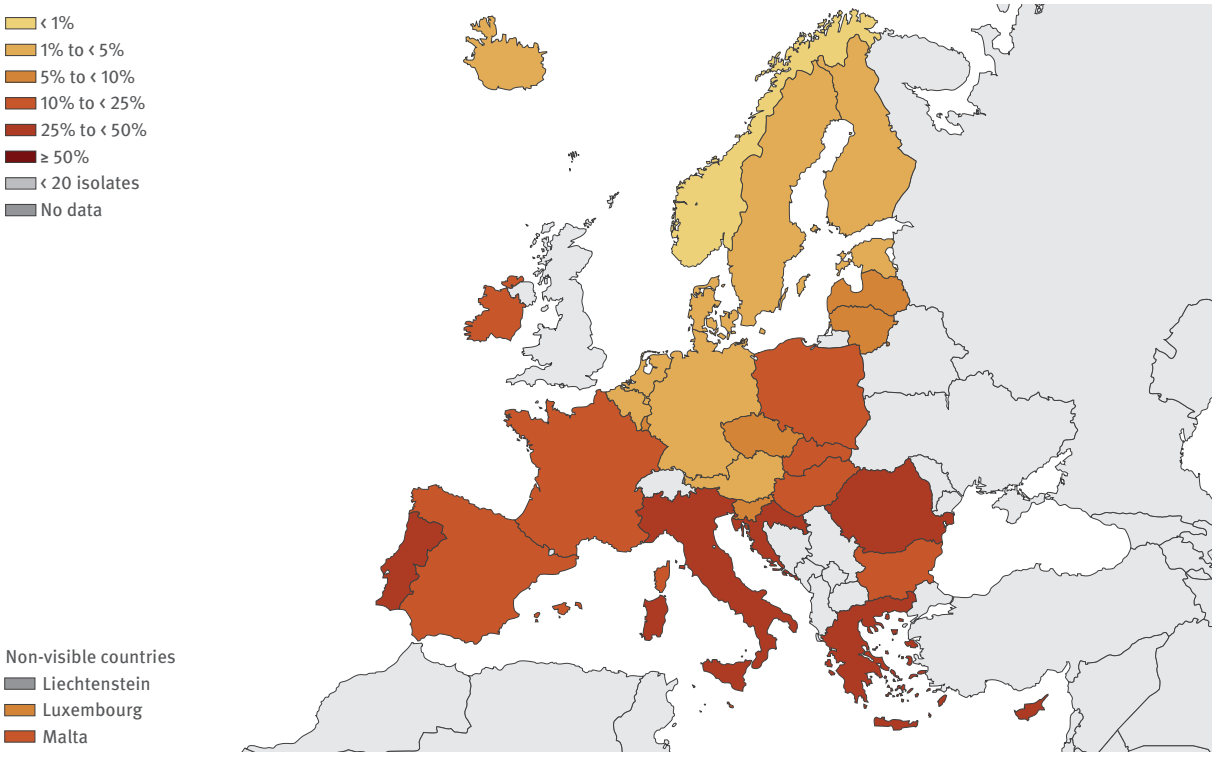
Large inter-country variations were noted for MRSA (Table 7a), with generally higher AMR percentages reported from southern and eastern Europe than northern Europe (Fig. 18).

Table 12 *Staphylococcus aureus*. Total number of invasive isolates tested (n = 60 432)[a] and AMR percentage (%) per phenotype, EU/EEA, 2021

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**50 016**	**82.8**
Single resistance (to indicated antimicrobial group)		
Total (any single resistance)	**4 887**	**8.1**
Fluoroquinolones	2 860	4.7
MRSA	1 778	2.9
Other antimicrobial groups	249	0.4
Resistance to two antimicrobial groups		
Total (any two-group combinations)	**5 220**	**8.6**
MRSA + fluoroquinolones	5 133	8.5
Other resistance combinations	87	0.1
Resistance to three antimicrobial groups		
MRSA + fluoroquinolones + rifampicin	309	0.5

[a] Only isolates with complete susceptibility information for MRSA, fluoroquinolones and rifampicin were included in the analysis. This represented 74.5% (60 432/81 163) of all reported *S. aureus* isolates. MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA. For fluoroquinolones (ciprofloxacin, levofloxacin or ofloxacin) AST results for norfloxacin are also accepted if neither ciprofloxacin, levofloxacin nor ofloxacin results are available.
[b] Only AMR combinations › 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.

Fig. 18 *Staphylococcus aureus*. Percentage of invasive isolates resistant to meticillin (MRSA),[a] by country, EU/EEA, 2021



[a] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
Administrative boundries: © EuroGeographics
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Discussion

In 2021, MRSA percentages were relatively stable or declining in several EU/EEA countries [12], and a decreasing EU/EEA population-weighted mean MRSA percentage was noted. Several countries have developed and implemented national recommendations and guidance documents on preventing the spread of MRSA, focusing on improved IPC and prudent antimicrobial use [30].

Despite this positive development, MRSA remains an important pathogen in Europe, and percentages are still high in several countries. *S. aureus* is one of the most common causes of bloodstream infections, exhibiting a high burden in terms of morbidity and mortality [13,22]. In ECDC's study of the EU/EEA health burden of AMR for the period 2016–2020, the second largest burden of disease was caused by infections with MRSA [13]. Although the EU/EEA population-weighted MRSA percentage, as reported by EARS-Net, has been decreasing for many years, ECDC's study of the health burden of AMR reported an increase in estimated MRSA incidence between 2007 and 2015. Further analysis of the age-group-specific incidence as part of the study found that this mainly related to infants and people aged 55 years or above [22]. A separate study based on EARS-Net data for the period 2005–2018 highlighted the fact that the decrease in the percentage of MRSA among *S. aureus* bloodstream infections was mainly due to the increasing number of meticillin-susceptible *S. aureus* bloodstream infections. The seemingly conflicting results highlight the need to improve surveillance of AMR by reporting not only AMR percentages but also the number and incidence of infections with antimicrobial-resistant bacteria such as MRSA [45].

Comprehensive MRSA strategies targeting all healthcare sectors are essential to slow down the spread of MRSA in Europe. At present, monitoring of MRSA in animals and food is voluntary and is only performed in a limited number of countries. Nevertheless, this monitoring detected MRSA, mainly livestock-associated MRSA (LA-MRSA), in food and food-producing animals in 2019–2020 [17]. LA-MRSA has gained attention, as it poses a zoonotic risk, particularly for those working in close contact with livestock. Although data collected through EARS-Net do not allow the identification of LA-MRSA isolates, an ECDC survey documented an increasing detection and geographical dispersion of LA-MRSA in humans in the EU/EEA during the period 2007–2013 and highlighted the veterinary and public health significance of LA-MRSA as a 'One-Health' issue [46].

Streptococcus pneumoniae

Epidemiology

For 2021, 28 EU/EEA countries reported 9 151 isolates of *S. pneumoniae*. This is a slight increase compared to 2020 (n=8 771) but continues to be considerably lower than for 2017–2019 (n=14 008–15 608). The low figure compared to previous years was also reflected in the number of reported isolates with AMR phenotype in the EU/EEA (Table 7b). Of the isolates reported, 8 465 (92.5%) had AST results for penicillins and 8 758 (95.7%) had AST results for macrolides (Table 7a).

Table 13 *Streptococcus pneumoniae*. Total number of invasive isolates tested (n = 5 952)[a] and percentage of non-wild-type/AMR (%) per phenotype, EU/EEA, 2021

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**4 512**	**75.8**
Single non-wild-type/resistance (to included antimicrobial groups)		
Total (any single resistance)	**855**	**14.4**
Penicillin non-wild-type[d]	402	6.8
Macrolides	385	6.5
Fluoroquinolones	67	1.1
Other antimicrobial group combinations	1	< 0.1
Non-wild-type/resistance to two antimicrobial groups		
Total (any two-group combinations)	**556**	**9.3**
Penicillin non-wild-type[d] + macrolides	535	9.0
Other antimicrobial group combinations	21	0.4
Non-wild-type/resistance to three antimicrobial groups		
Total (any three-group combinations)	**28**	**0.5**
Other antimicrobial group combinations	28	0.5
Non-wild-type/resistance to four antimicrobial groups		
Penicillin non-wild-type[d] + third-generation cephalosporins + fluoroquinolones + macrolides	1	< 0.1

[a] Only isolates with complete susceptibility information for penicillins (based on penicillin or, if unavailable, oxacillin), third-generation cephalosporins (cefotaxime or ceftriaxone) and fluoroquinolones (levofloxacin or moxifloxacin – AST results for norfloxacin are also accepted if neither levofloxacin nor moxifloxacin results are available) and macrolides (azithromycin, clarithromycin or erythromycin) were included in the analysis. This represented 65.0% (5 952/9 151) of all reported *S. pneumoniae* isolates.
[b] Only AMR combinations > 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.
[d] For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by local laboratories as susceptible, increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data.

For this report, the term penicillin non-wild-type refers to *S. pneumoniae* isolates reported by local laboratories as susceptible, increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of the wild-type isolates (› 0.06 mg/L). The analysis was based on the qualitative susceptibility categories S/I/R, since quantitative susceptibility information was missing for a large part of the reported data.

More than one fifth (24.2%) of the *S. pneumoniae* isolates reported by EU/EEA countries to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (penicillins, third-generation cephalosporins, fluoroquinolones and macrolides) (Table 13). In 2021, the EU/EEA population-weighted mean percentage was 16.3% for penicillin non-wild-type and 18.3% for macrolide resistance (Table 7a).

Between 2017 and 2021, the trend in the percentage of penicillin non-wild-type resistance in the EU/EEA increased significantly, with percentages increasing from 14.0% to 16.3% (Table 7b). This trend remained significant when the analysis was restricted to include only laboratories that continuously reported data for all five years. Although no significant increase in trend was noted for resistance to macrolides, there was a relatively large annual increase in AMR percentage at EU/EEA level in 2021 (1.5%) compared with the annual changes in AMR percentage at EU/EEA level during the period 2017–2020 (Table 7b).

The EU/EEA population-weighted mean percentage for combined penicillin non-wild-type and resistance to macrolides was 9.9% in 2021 but no significant trend was noted during the period 2017 to 2021 (Table 7b). Resistance to antimicrobial groups other than penicillin and macrolides was less common (Table 13).

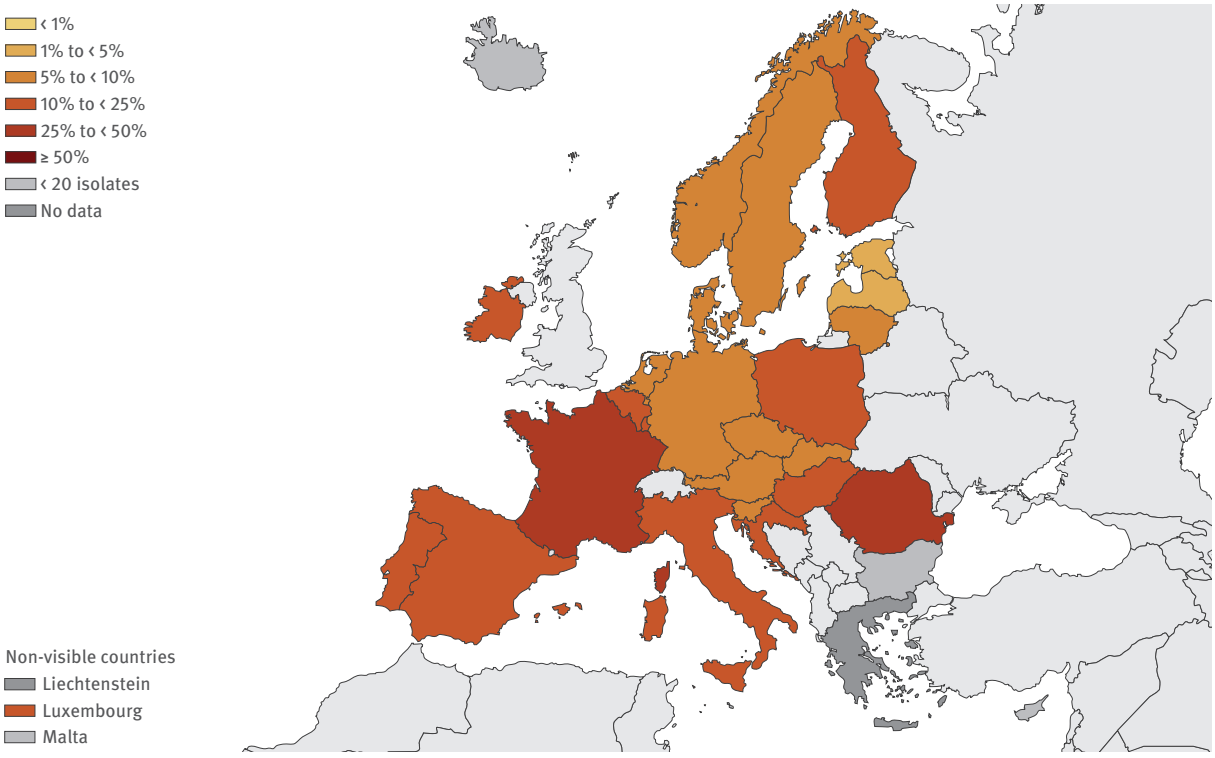
Large inter-country variations were noted for all antimicrobial groups (Table 7a, Fig. 19), with generally higher macrolide resistance percentages reported from southern and eastern Europe than northern Europe.

Discussion

Decreased circulation of pathogens in the community as a result of NPIs introduced to reduce SARS-CoV-2 transmission could potentially explain the decrease in the number of *S. pneumoniae* isolates reported by EU/EEA countries for 2020 and 2021 compared to 2017–2019.

Although the number of reported *S. pneumoniae* has decreased, there was an increasing trend in the population-weighted EU/EEA mean percentages for penicillin non-wild-type between 2017 and 2021. However, there were large inter-country variations. Differences in the clinical breakpoints used historically to determine penicillin susceptibility in *S. pneumoniae* (based on

Fig. 19 *Streptococcus pneumoniae*. Percentage of penicillin[a] non-wild-type[b] invasive isolates, by country, EU/EEA, 2021



[a] Penicillin results are based on penicillin or, if unavailable, oxacillin.
[b] For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by local laboratories as susceptible, increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (› 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data.

the guidelines used and the sites of infection) could introduce bias when comparing national data reported to EARS-Net before 2021. (Since 2019, there has been a restriction introduced into EUCAST guidelines which should lessen this particular aspect in the future). Limited information on the guidelines and breakpoints used for interpretation and incomplete quantitative susceptibility data hamper assessment of inter-country differences to some extent and may also influence the assessment of changes over time.

In parallel with EARS-Net, surveillance of invasive pneumococcal disease in the EU/EEA is covered by another surveillance network - the European Invasive Bacterial Disease Surveillance Network (EU-IBD), also coordinated by ECDC. This network collects additional data on invasive pneumococcal disease cases throughout the EU/EEA – e.g. data on outcome [47]. Data from this surveillance show that the percentage of resistance to penicillin was 2% and to erythromycin 18%, based on the reporting of antimicrobial susceptibility data by 10 countries in 2018 [47]. It is, however, difficult to compare data from the two surveillance systems due to differences – e.g. the number of reporting countries.

Most EU/EEA countries have implemented routine immunisation for children with multivalent pneumococcal conjugated vaccines (PCVs). In some countries, high-risk adult groups, such as elderly people and immunocompromised individuals, are also targeted with the polysaccharide vaccine or with PCVs [48]. Changes in immunisation and serotype coverage of the PCVs available will probably have an impact on the epidemiology of *S. pneumoniae* in the EU/EEA, both in terms of changes in the age-specific incidence and potential serotype replacement. It is also conceivable that the ongoing COVID-19 pandemic and related public health interventions and changes in antibiotic consumption [49] may further affect *S. pneumoniae* epidemiology in the EU/EEA.

Enterococcus faecalis

Epidemiology

For 2021, 29 EU/EEA countries reported 32 337 isolates of *E. faecalis* – 16 301 (50.4%) with AST results for high-level gentamicin (Table 7a). Over the last five years the number of reported isolates of *E. faecalis* at EU/EEA level has increased by 59.3% from 20 299 isolates in 2017. At the same time the number of reported isolates with AMR phenotype in the EU/EEA increased from 13 930 in 2017.

In 2021, the EU/EEA population-weighted mean percentage of high-level gentamicin resistance in *E. faecalis* was 29.0%. This represents a small decrease since 2017, when the percentage was 29.7%, and no change compared to 2020, when the percentage was 29.0% (Table 7b).

Large inter-country variations were noted for high-level gentamicin resistance in *E. faecalis* (Table 7a), with generally higher AMR percentages reported from southern and eastern Europe than northern Europe, with a few exceptions (see country profiles in Chapter 4). More information is provided in ECDC's Surveillance Atlas of Infectious Diseases [12].

Discussion

While the number of isolates has increased, the essentially unchanged high-level gentamicin resistance level in *E. faecalis* noted by EARS-Net indicates that high levels of antimicrobial-resistant enterococci remain a major IPC challenge and an important cause of healthcare-associated infections in Europe. In addition to the fact that infections caused by resistant strains are difficult to treat, enterococci are also easily disseminated in healthcare settings.

Enterococcus faecium

Epidemiology

For 2021, 29 EU/EEA countries reported 22 621 isolates of *E. faecium* – 22 315 (98.6%) with AST results for vancomycin (Table 7a).

More than nine-tenths (93.0%) of the *E. faecium* isolates reported by EU/EEA countries to EARS-Net for 2021 were resistant to at least one of the antimicrobial groups under surveillance (aminopenicillins, gentamicin (high-level resistance) and vancomycin) (Table 14).

AMR to two or more antimicrobial groups was common - seen in 56.4% of all tested isolates (Table 14).

The EU/EEA population-weighted mean percentage of vancomycin resistance in *E. faecium* was 17.2% in 2021, representing a significant increase since 2017 when the percentage was 13.4%. The trend remained significant when the analysis was restricted to include only laboratories that continuously reported data for all five years.

National percentages ranged from 0.0% to 66.4% (Table 7a) and only 10 of the 29 EU/EEA countries reported AMR percentages below 5.0% (Fig. 20). High vancomycin-resistant *E. faecium* levels were reported from countries in central, southern, and eastern Europe, as well as Ireland.

Discussion

The rapid and continuous increase in the percentage of vancomycin resistance in *E. faecium* in the EU/EEA is a cause for concern. A previous ECDC study of the AMR health burden estimated that the median number of infections and deaths attributable to vancomycin-resistant enterococci almost doubled between 2007 and 2015 [22]. A more recent ECDC study estimated that these infections increased from 47 124 in 2016 to 117 866 in 2020, with a concomitant increase in the number of attributable deaths from 1 335 to 3 414 [13]. The rise in the vancomycin resistance percentage for *E. faecium* in 2021 noted in this report contributes to a further increase in the health burden of vancomycin-resistant enterococci infections.

The significantly increasing trend, observed at EU/EEA level and in some individual countries, highlights the urgent need for close monitoring to better understand

the epidemiology, clonal diversity and risk factors associated with vancomycin-resistant *E. faecium* infection. Contrary to many other bacterial species–antimicrobial group combinations under surveillance by EARS-Net, the geographical pattern for vancomycin-resistant *E. faecium* was slightly different, indicating high AMR levels reported from countries in central, southern and eastern Europe, as well as Ireland.

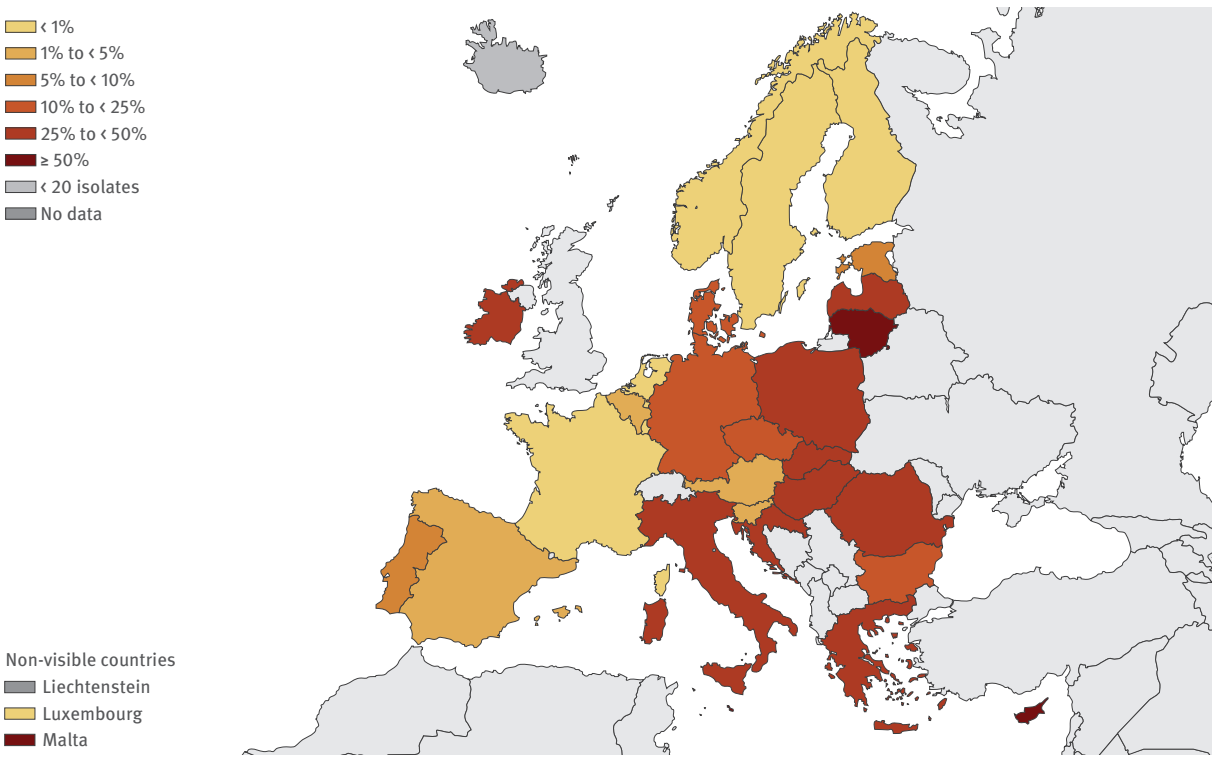
Enterococci have intrinsic resistance to several antimicrobial classes, and any additional acquired AMR severely limits the number of treatment options. WHO has listed vancomycin-resistant *E. faecium* as a pathogen of high priority in its global priority list of antibiotic-resistant bacteria, emphasising the paucity of available and effective treatment options [33]. High levels of antimicrobial-resistant enterococci remain a major infection control challenge and an important cause of healthcare-associated infections in Europe. In addition to the fact that infections caused by resistant strains are difficult to treat, enterococci are also easily disseminated in healthcare settings.

Table 14 *Enterococcus faecium*. Total number of invasive isolates tested (n = 11 586)[a] and AMR percentage (%) per phenotype, EU/EEA, 2021

AMR pattern[b]	Number of isolates	Percentage of total[c]
Fully susceptible (to included antimicrobial groups)	**808**	**7.0**
Single resistance (to indicated antimicrobial group)		
Total (any single resistance)	**4 242**	**36.6**
Aminopenicillins	4 174	36.0
Other antimicrobial groups	68	0.6
Resistance to two antimicrobial groups		
Total (any two-group combinations)	**5 236**	**45.2**
Aminopenicillins + gentamicin (high-level resistance)	4 035	34.8
Aminopenicillins + vancomycin	1 194	10.3
Other resistance combinations	7	0.1
Resistance to three antimicrobial groups		
Aminopenicillins + gentamicin (high-level resistance) + vancomycin	1 300	11.2

[a] Only isolates with complete susceptibility information for aminopenicillins (ampicillin or amoxicillin), gentamicin (high-level resistance) and vancomycin were included in the analysis. This represented 51.2% (11 586/22 621) of all reported *E. faecium* isolates.
[b] Only AMR combinations > 1% of the total are specified.
[c] Not adjusted for population differences in the reporting countries.

Fig. 20 *Enterococcus faecium*. Percentage of invasive isolates resistant to vancomycin, by country, EU/EEA, 2021



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4. Country profiles

Armenia

Participating institutions

National Center for Disease Control and Prevention

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Armenia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	ND	ND	ND
Geographical representativeness	ND	Low	Low	ND	Low
Hospital representativeness	ND	Low	Low	ND	Low
Isolate representativeness	ND	Low	Low	ND	Low
Blood culture sets/1 000 patient days[a]	ND	3 (1–3)	7 (2–9)	ND	6 (2–10)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Armenia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	ND	90	100	ND	100
Percentage of laboratories participating in CAESAR EQA	ND	100	100	ND	100

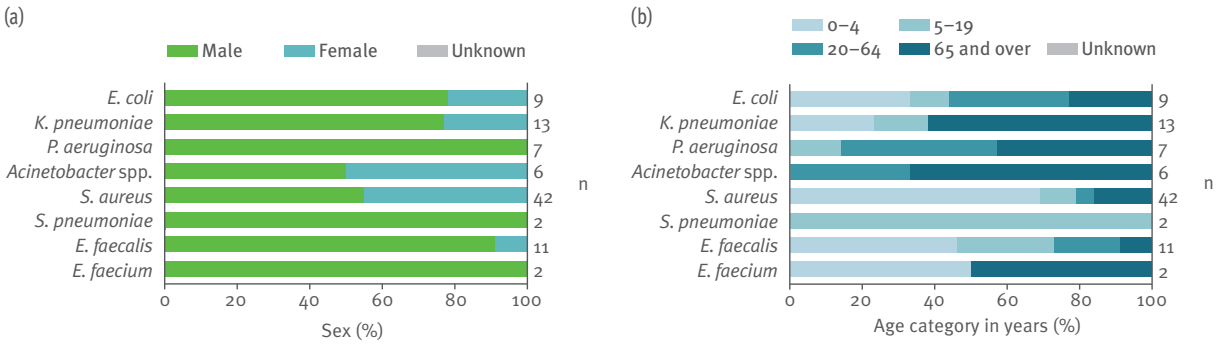
ND: no data available.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Armenia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	ND	ND	ND	4	11	NA	4	10	NA	ND	ND	ND	4	9	NA
K. pneumoniae	ND	ND	ND	3	6	NA	1	2	NA	ND	ND	ND	4	13	NA
P. aeruginosa	ND	ND	ND	1	2	NA	3	6	NA	ND	ND	ND	3	7	NA
Acinetobacter spp.	ND	ND	ND	1	1	NA	1	1	NA	ND	ND	ND	2	6	NA
S. aureus	ND	ND	ND	4	17	NA	4	13	NA	ND	ND	ND	4	42	74
S. pneumoniae	ND	ND	ND	1	1	NA	1	1	NA	ND	ND	ND	2	2	NA
E. faecalis	ND	ND	ND	2	3	NA	2	2	NA	ND	ND	ND	3	11	NA
E. faecium	ND	ND	ND	2	3	NA	ND	ND	ND	ND	ND	ND	2	2	NA

Labs: laboratories.
ND: no data available.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Armenia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Armenia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	ND	ND	11	NA	10	NA	ND	ND	9	NA	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	11	NA	10	NA	ND	ND	9	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	11	NA	9	NA	ND	ND	9	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	11	NA	10	NA	ND	ND	9	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	11	NA	7	NA	ND	ND	8	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	11	NA	7	NA	ND	ND	8	NA	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	6	NA	2	NA	ND	ND	13	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	6	NA	2	NA	ND	ND	11	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	6	NA	2	NA	ND	ND	13	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	6	NA	2	NA	ND	ND	13	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	6	NA	2	NA	ND	ND	13	NA	NA
P. aeruginosa	Piperacillin-tazobactam resistance	ND	ND	2	NA	6	NA	ND	ND	6	NA	NA
	Ceftazidime resistance	ND	ND	2	NA	5	NA	ND	ND	7	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	2	NA	5	NA	ND	ND	7	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	2	NA	6	NA	ND	ND	7	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	ND	ND	2	NA	5	NA	ND	ND	7	NA	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	ND	ND	2	NA	3	NA	ND	ND	6	NA	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	ND	ND	1	NA	1	NA	ND	ND	6	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	1	NA	1	NA	ND	ND	6	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	1	NA	1	NA	ND	ND	6	NA	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	ND	ND	1	NA	1	NA	ND	ND	6	NA	NA
S. aureus	MRSA[d]	ND	ND	17	NA	13	NA	ND	ND	42	28.6	NA
S. pneumoniae	Penicillin non-wild-type[e]	ND	ND	1	NA	1	NA	ND	ND	2	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	ND	ND	1	NA	1	NA	ND	ND	2	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	ND	ND	1	NA	1	NA	ND	ND	2	NA	NA
E. faecalis	High-level gentamicin resistance	ND	ND	3	NA	2	NA	ND	ND	11	NA	NA
E. faecium	Vancomycin resistance	ND	ND	3	NA	ND	ND	ND	ND	2	NA	NA

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (>0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

Austria

Participating institutions

Federal Ministry of Health and Women's Affairs
Medical University Vienna
Ordensklinikum Linz, Elisabethinen

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Austria, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	ND	ND	ND
Geographical representativeness	ND	High	High	High	High
Hospital representativeness	ND	High	High	High	High
Isolate representativeness	ND	High	High	High	High
Blood culture sets/1 000 patient days	ND	24.2	ND	ND	ND

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Austria, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	97	95	NA	100

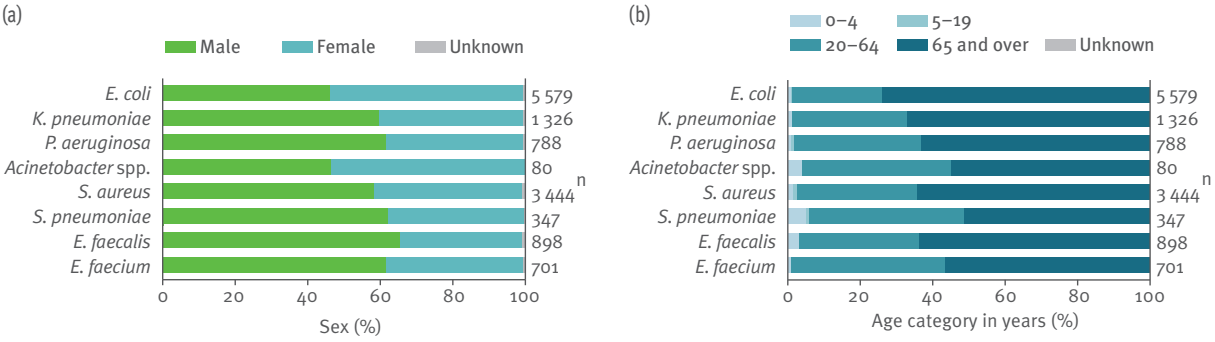
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Austria, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	39	5381	9	38	5686	9	38	6305	8	37	5394	8	37	5579	7
K. pneumoniae	39	1152	14	38	1228	14	38	1333	14	36	1133	17	36	1326	15
P. aeruginosa	39	725	16	38	737	16	38	808	13	36	727	18	36	788	16
Acinetobacter spp.	25	75	11	28	95	12	23	82	13	22	69	12	25	80	16
S. aureus	39	3162	14	38	3310	13	38	3419	12	36	2934	14	36	3444	14
S. pneumoniae	39	513	19	38	567	18	37	550	18	34	301	10	33	347	16
E. faecalis	38	769	19	38	837	17	37	792	16	35	840	21	36	898	23
E. faecium	38	573	31	35	524	28	34	537	33	32	509	30	31	701	36

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Austria, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Austria, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	5188	49.5	5456	50.7	6042	46.3	4798	46.0	4805	45.1	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	5129	9.6	5672	10.2	6106	9.3	5376	9.5	5537	8.3	13.8 (5.5–37.3)	↓*
	Carbapenem (imipenem/meropenem) resistance	5227	0.0	5564	0.1	5935	0.0	5141	0.1	5206	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	5367	20.5	5679	21.9	6111	18.2	5373	17.3	5539	15.1	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	5318	7.7	5616	8.2	6102	6.9	5219	6.2	5320	5.8	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	5071	3.3	5598	3.6	6072	2.7	5192	2.8	5286	1.7	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1072	8.6	1221	8.4	1326	10.3	1124	7.8	1305	9.8	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	1109	1.0	1184	1.0	1296	1.2	1055	0.9	1229	1.0	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1147	14.2	1221	13.2	1327	15.7	1129	12.0	1303	12.0	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1141	4.8	1214	4.8	1319	5.5	1085	3.7	1235	3.4	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1062	3.0	1203	3.1	1312	3.0	1076	2.8	1227	2.2	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	628	10.4	650	10.6	665	9.5	624	9.0	643	10.1	18.7 (0.0–47.2)	–
	Ceftazidime resistance	620	8.7	729	10.3	781	8.5	688	9.4	741	13.0	15.8 (2.3–46.0)	↑*
	Carbapenem (imipenem/meropenem) resistance	725	13.9	736	12.8	786	13.4	683	15.1	737	15.9	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	721	12.3	736	14.0	805	10.7	676	14.3	722	16.6	18.7 (3.3–48.0)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	717	5.0	729	6.3	784	3.8	426	2.6	438	4.1	8.9 (0.0–41.7)	↓
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	586	6.1	639	5.3	633	5.1	355	3.9	279	4.3	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	75	6.7	91	4.4	81	7.4	69	7.2	70	10.0	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	74	9.5	91	7.7	82	9.8	69	10.1	80	13.8	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	75	9.3	92	8.7	82	7.3	66	7.6	75	10.7	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	74	6.8	88	4.5	81	6.2	66	6.1	70	10.0	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	3158	5.9	3307	6.4	3323	5.2	2843	4.4	3159	3.1	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	463	6.0	523	6.3	458	6.8	258	3.9	324	5.2	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	507	10.8	562	11.6	547	12.4	295	11.5	335	14.3	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	457	3.3	519	3.3	455	3.5	252	2.4	315	2.5	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	474	33.1	417	28.3	285	22.8	258	14.3	255	14.5	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	570	3.2	524	2.1	537	3.2	507	3.6	697	2.0	17.2 (0.0–66.4)	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Belarus

Participating institutions

Laboratory for Clinical and Experimental Microbiology, Republican Research and Practical Center for Epidemiology and Microbiology

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Belarus, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	>90	>90	>90	99	99
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Low	Low	Low	Low	Low
Blood culture sets/1 000 patient days[a]	ND	ND	ND	6 (2–97)	8 (0–416)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Belarus, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	ND	25	25	25	25
Percentage of laboratories participating in CAESAR EQA	25	29	14	13	NA

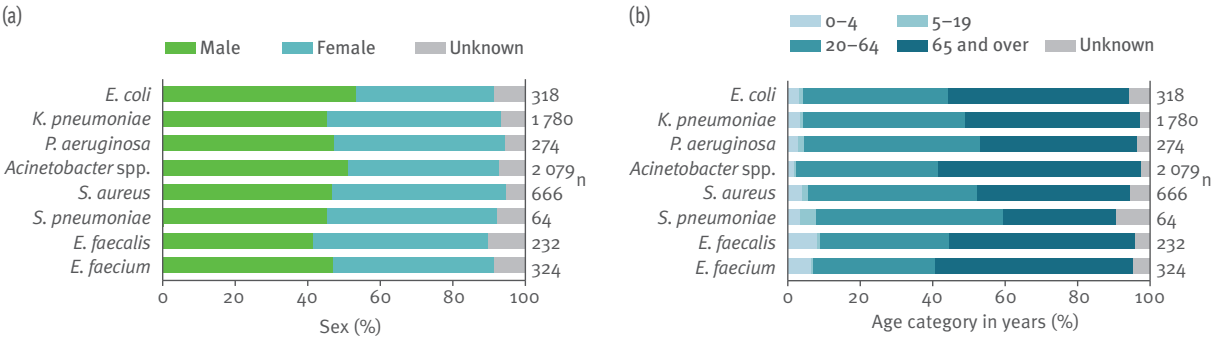
ND: no data available.
NA: not applicable.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Belarus, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	29	154	58	23	145	57	23	146	43	38	53	45	45	318	50
K. pneumoniae	29	494	59	27	589	64	35	575	61	39	66	58	58	1780	72
P. aeruginosa	20	97	70	13	74	66	20	55	73	24	55	37	37	274	77
Acinetobacter spp.	24	359	63	23	406	64	27	359	74	39	72	51	51	2079	81
S. aureus	35	329	43	30	365	46	38	353	43	43	42	58	58	666	52
S. pneumoniae	12	31	77	11	37	59	13	33	64	11	55	19	19	64	72
E. faecalis	21	145	48	16	116	48	18	112	42	24	53	31	31	232	69
E. faecium	18	98	58	13	112	59	20	81	52	20	67	24	24	324	61

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Belarus, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Belarus, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	71	70.4	39	69.2	89	65.2	132	74.2	124	69.2	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	150	48.0	137	52.6	135	43.0	216	50.5	123	49.6	NA
	Carbapenem (imipenem/meropenem) resistance	150	8.7	136	2.9	137	4.4	218	5.0	28	9.7[f]	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	145	44.8	140	45.0	139	41.7	219	45.2	127	42.3	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	81	25.9	56	30.4	109	12.8	165	23.0	42	19.1	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	79	24.1	55	21.8	101	8.9	159	14.5	25	14.2[f]	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	474	86.9	535	86.5	535	87.3	864	91.2	1245	92.3	NA
	Carbapenem (imipenem/meropenem) resistance	464	72.6	563	76.4	548	75.9	930	85.1	1464	86.7	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	471	84.5	568	85.0	531	87.4	887	89.7	1521	90.0	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	286	76.2	184	74.5	357	70.6	572	73.1	739	77.6	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	266	74.4	168	72.0	322	71.7	534	72.1	574	77.3	NA
P. aeruginosa	Piperacillin-tazobactam resistance	50	44.0	20	50.0[f]	24	45.8[f]	50	66.0	103	60.2	NA
	Ceftazidime resistance	75	65.3	49	65.3	43	62.8	69	59.4	101	60.4	NA
	Carbapenem (imipenem/meropenem) resistance	93	78.5	69	68.1	52	82.7	107	74.8	103	60.2	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	94	75.5	72	68.1	46	80.4	99	73.7	103	60.2	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	53	62.3	29	65.5[f]	31	67.7	46	69.6	73	64.4	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	29	48.3[f]	14	NA	17	NA	34	73.5	72	63.9	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	349	87.4	393	93.6	346	93.4	798	94.0	1879	96.0	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	348	94.3	396	93.2	345	95.1	746	96.4	1857	94.7	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	206	73.3	141	68.8	181	68.5	479	84.8	840	78.6	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	196	61.7	130	68.5	166	66.3	438	83.8	786	78.4	NA
S. aureus	MRSA[d]	299	40.8	331	37.5	305	36.4	354	34.5	57	30.0	NA
S. pneumoniae	Penicillin non-wild-type[e]	17	NA	23	17.4[f]	16	NA	29	31.0[f]	36	50.0	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	27	22.2[f]	34	26.5	25	32.0[f]	29	41.4[f]	53	47.2	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	17	NA	22	13.6[f]	13	NA	28	25.0[f]	36	33.3	NA
E. faecalis	High-level gentamicin resistance	113	66.4	73	65.8	87	66.7	157	68.2	185	65.9	NA
E. faecium	Vancomycin resistance	96	16.7	110	17.3	77	22.1	160	20.0	306	5.2	NA

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Belgium

Participating institutions

Sciensano

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Belgium, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	30				
Laboratories collecting *S. pneumoniae*		86	87	91	91
Laboratories collecting others species		30	26	36	43
Geographical representativeness	High				
Laboratories collecting *S. pneumoniae*		High	High	High	High
Laboratories collecting others species		Medium	Medium	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	ND	99.1[a]	87.5[a]	129.6[a]	100.8[a]

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.
[a] Not including *S. pneumoniae* network.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Belgium, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	68	91	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	90	82	91	NA	94

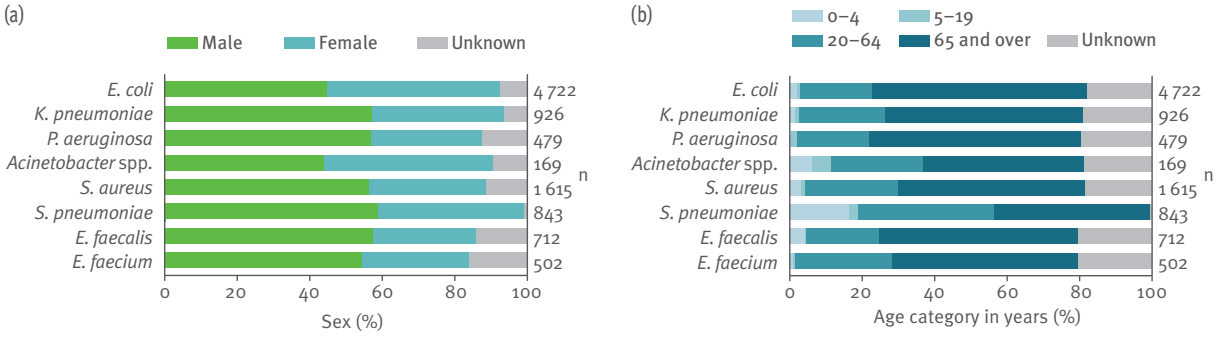
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Belgium, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	32	4676	NA	32	4675	NA	27	3940	NA	28	4320	NA	31	4722	NA
K. pneumoniae	31	803	NA	31	956	NA	26	759	NA	27	912	NA	30	926	NA
P. aeruginosa	31	474	NA	30	490	NA	27	441	NA	28	504	NA	30	479	NA
Acinetobacter spp.	21	131	NA	26	134	NA	23	94	NA	23	161	NA	28	169	NA
S. aureus	31	1531	NA	31	1750	NA	27	1169	NA	28	1455	NA	30	1615	NA
S. pneumoniae	91	1472	23	88	1526	NA	89	1548	NA	89	858	27	82	843	24
E. faecalis	31	551	NA	31	615	NA	26	496	NA	29	669	NA	31	712	NA
E. faecium	30	418	NA	30	441	NA	25	343	NA	26	494	NA	29	502	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Belgium, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Belgium, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	4 669	57.5	4445	55.8	3601	56.5	4 009	56.5	4 389	55.2	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	4672	9.7	4644	9.0	3937	10.0	4320	9.9	4721	8.3	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	4672	0.0	4641	0.1	3926	0.1	4126	0.0	4722	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	4382	23.8	4211	21.8	3925	19.1	4320	18.1	4721	18.5	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	3769	8.1	3822	7.4	3922	6.9	4 312	7.5	4267	6.1	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	3765	3.5	3809	3.1	3920	3.0	4 312	2.9	4265	1.7	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	803	19.3	935	21.4	759	19.5	912	19.7	926	18.9	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	791	1.1	935	1.4	757	1.1	881	1.1	926	1.4	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	803	23.7	932	22.6	757	19.8	911	22.8	926	19.0	33.6 (0.0–80.0)	↓
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	633	12.5	747	12.4	755	11.4	910	13.1	858	9.7	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	633	8.5	742	9.8	755	8.7	909	10.3	858	7.9	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	438	10.5	430	10.0	439	12.1	503	11.1	478	10.0	18.7 (0.0–47.2)	–
	Ceftazidime resistance	431	7.2	441	7.5	427	8.2	489	9.0	464	8.0	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	474	8.2	487	7.4	440	10.7	474	12.4	479	10.6	18.1 (3.5–45.9)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	430	10.5	451	14.0	440	14.3	503	14.7	479	14.0	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	377	7.7	406	8.4	438	7.1	304	6.3	257	7.0	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	360	6.7	366	5.5	423	6.1	289	8.0	243	8.2	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	131	6.9	132	3.8	94	0.0	160	1.3	167	1.2	39.9 (0.0–99.5)	↓*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	130	10.8	134	12.7	93	8.6	141	15.6	146	12.3	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	99	13.1	122	7.4	85	3.5	148	2.7	153	5.2	39.6 (2.1–98.8)	↓*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	98	7.1	120	3.3	84	0.0	127	0.8	130	1.5	36.8 (0.0–98.5)	↓*
S. aureus	MRSA[f]	1511	8.5	1735	9.0	1168	6.7	1455	6.9	1614	4.1	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	1472	0.2	1526	0.1	1548	9.7	858	14.5	843	18.0	16.3 (3.6–35.7)	↑*
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	1472	15.1	1526	15.2	1548	15.7	858	19.1	843	16.5	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	1472	0.1	1526	0.1	1548	5.7	858	8.7	843	9.8	9.9 (0.0–28.0)	↑*
E. faecalis	High-level gentamicin resistance	304	16.4	390	12.3	363	16.8	296	13.2	351	8.5	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	417	5.5	436	1.8	343	0.6	491	2.9	502	2.8	17.2 (0.0–66.4)	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Bosnia and Herzegovina

Participating institutions

Clinical Microbiology Department, Clinical Center University of Sarajevo
Department of Clinical Microbiology, University Clinical Center

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Bosnia and Herzegovina, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	77	77	77	77	77
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Medium	Medium	Medium	Medium	Medium
Blood culture sets/1 000 patient days[a]	9 (3–19)	7 (3–24)	8 (3–30)	9 (4–52)	19 (6–52)

Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Bosnia and Herzegovina, 2017–2021

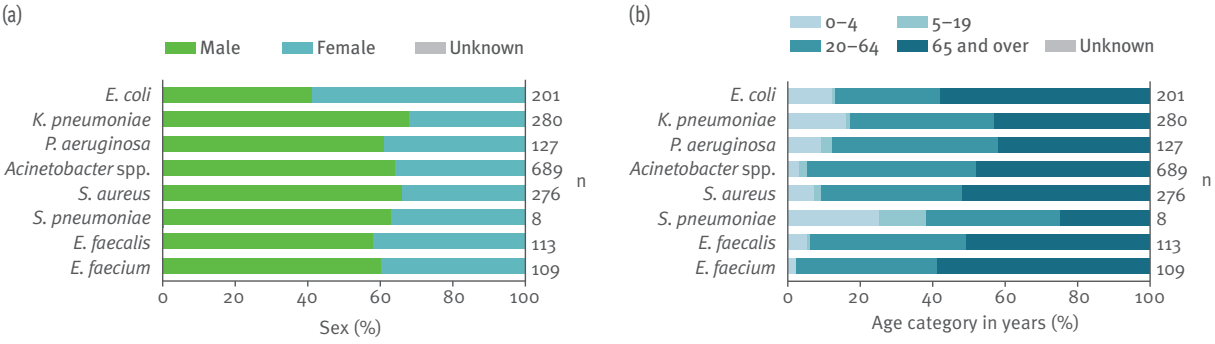
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	67	92	92	80
Percentage of laboratories participating in CAESAR EQA	100	83	92	92	100

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Bosnia and Herzegovina, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	9	195	5	10	250	9	10	291	9	10	179	20	9	201	7
K. pneumoniae	8	152	20	11	207	34	11	211	34	10	207	48	9	280	51
P. aeruginosa	7	57	19	9	79	28	7	81	30	10	104	52	8	127	56
Acinetobacter spp.	6	124	48	8	141	61	8	229	64	10	348	69	9	689	81
S. aureus	9	158	19	11	228	15	9	237	15	11	198	27	9	276	21
S. pneumoniae	6	33	6	9	42	19	6	44	5	4	20	25[c]	3	8	NA
E. faecalis	7	70	20	9	93	22	8	81	21	8	82	24	10	113	40
E. faecium	5	40	50	6	48	33	7	65	61	9	85	53	8	109	58

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Bosnia and Herzegovina, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Bosnia and Herzegovina, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	159	73.0	250	68.8	290	71.4	179	66.5	201	71.1	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	195	24.6	250	20.0	290	20.7	179	24.0	201	28.9	–
	Carbapenem (imipenem/meropenem) resistance	184	1.1	249	0.0	290	0.0	179	0.0	200	0.5	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	189	26.5	248	24.2	289	29.8	179	19.6	201	34.8	–
	Aminoglycoside (gentamicin/tobramycin) resistance	190	24.7	250	17.2	290	20.3	179	31.3	201	39.3	⇡*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	187	13.4	248	10.5	289	9.7	179	12.8	201	15.4	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	152	60.5	207	70.5	211	79.6	207	75.8	280	78.2	⇡*
	Carbapenem (imipenem/meropenem) resistance	147	10.9	207	18.4	211	41.7	207	43.5	280	37.1	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	147	54.4	207	59.4	210	67.6	207	61.4	279	66.3	⇡*
	Aminoglycoside (gentamicin/tobramycin) resistance	150	63.3	207	68.6	211	78.7	207	72.0	280	74.3	⇡*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	145	43.4	207	54.6	210	63.3	207	55.1	279	60.9	⇡*
P. aeruginosa	Piperacillin-tazobactam resistance	57	22.8	79	24.1	77	14.3	104	28.8	127	29.9	–
	Ceftazidime resistance	57	19.3	79	30.4	81	34.6	104	30.8	127	37.0	⇡*
	Carbapenem (imipenem/meropenem) resistance	57	22.8	79	30.4	81	46.9	104	52.9	127	37.0	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	57	45.6	79	43.0	81	56.8	104	42.3	127	40.2	–
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	57	43.9	79	40.5	81	48.1	101	27.7	127	36.2	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	57	33.3	79	32.9	77	42.9	101	30.7	127	28.3	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	124	95.2	141	92.9	229	96.5	348	97.7	689	98.7	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	123	95.9	141	99.3	229	97.8	348	98.6	689	98.7	–
	Aminoglycoside (gentamicin/tobramycin) resistance	124	95.2	141	98.6	229	96.5	348	94.8	689	99.7	⇡*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	123	93.5	141	92.9	229	93.4	348	94.3	689	98.5	⇡*
S. aureus	MRSA[d]	158	25.9	228	16.2	237	10.5	198	19.2	274	16.8	–
S. pneumoniae	Penicillin non-wild-type[e]	33	42.4	42	52.4	44	34.1	20	30.0[f]	8	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	30	36.7	42	35.7	44	34.1	20	55.0[f]	8	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	30	33.3	42	28.6	44	25.0	20	25.0[f]	8	NA	NA
E. faecalis	High-level gentamicin resistance	69	59.4	92	37.0	81	70.4	82	72.0	113	57.5	–
E. faecium	Vancomycin resistance	40	35.0	48	37.5	65	38.5	85	52.9	109	45.9	–

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ⇡ and ⇣ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Bulgaria

Participating institutions

National Center of Infectious and Parasitic Diseases

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Bulgaria, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	30	46	45	45	45
Geographical representativeness	Medium	Medium	Medium	Medium	Medium
Hospital representativeness	Low	Low	Medium	Medium	Medium
Isolate representativeness	High	Medium	Medium	Medium	Medium
Blood culture sets/1 000 patient days	8.3	8.5	8.6	10.4	11.4

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Bulgaria, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	95	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	95	100	100	NA	96

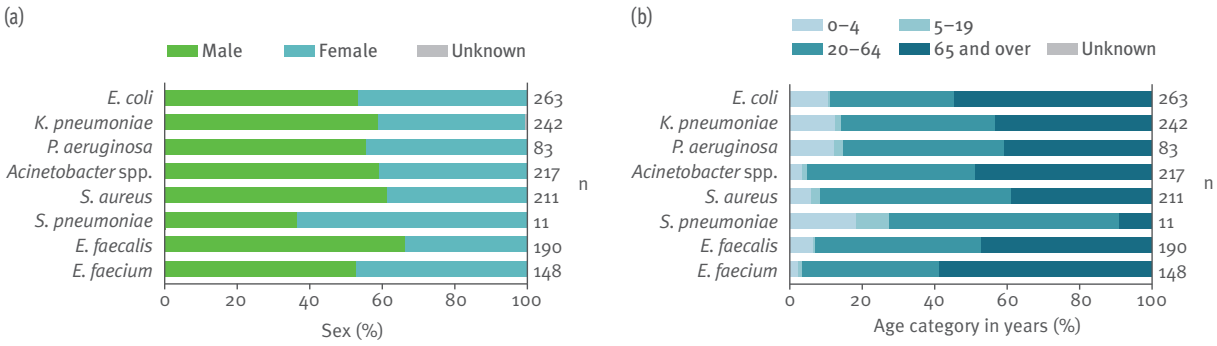
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Bulgaria, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	20	247	20	22	292	22	23	352	23	23	261	19	22	263	15
K. pneumoniae	18	169	41	21	193	47	20	267	53	19	249	48	19	242	47
P. aeruginosa	16	71	28	18	90	36	16	107	40	17	70	51	15	83	45
Acinetobacter spp.	15	92	64	19	110	66	15	132	60	14	129	60	18	217	70
S. aureus	18	227	25	22	313	29	23	324	23	23	220	22	19	211	15
S. pneumoniae	12	29	38[c]	14	42	17	14	46	35	9	28	21[c]	6	11	NA
E. faecalis	17	133	28	20	150	34	20	150	35	19	165	41	21	190	37
E. faecium	17	84	42	20	91	49	17	99	31	16	77	57	13	148	62

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Bulgaria, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Bulgaria, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	203	73.9	287	66.6	352	63.4	261	66.7	263	61.2	53.1 (31.7–70.2)	⇣*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	247	41.3	292	38.7	352	38.6	261	41.4	263	37.3	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	247	0.0	292	1.4	352	0.0	261	0.8	263	0.4	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	247	42.1	292	41.8	352	38.6	261	42.9	263	33.5	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	229	36.2	275	28.4	352	24.4	219	34.2	263	27.0	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	229	24.9	275	19.6	352	19.0	219	18.7	263	14.8	5.1 (1.2–14.8)	⇣*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	169	76.3	193	77.7	267	75.7	249	79.1	242	81.4	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	169	12.4	193	21.2	267	27.0	249	28.1	242	46.3	11.7 (0.0–73.7)	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	169	59.8	193	62.7	267	60.7	249	67.1	242	71.1	33.6 (0.0–80.0)	⇡*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	168	63.1	191	59.2	267	57.3	230	67.0	242	69.0	23.7 (0.0–69.1)	⇡
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	168	50.0	191	47.6	267	44.9	230	57.4	242	59.9	21.2 (0.0–67.4)	⇡*
P. aeruginosa	Piperacillin-tazobactam resistance	69	33.3	89	32.6	107	31.8	70	64.3	83	43.4	18.7 (0.0–47.2)	⇡*
	Ceftazidime resistance	71	38.0	90	20.0	107	30.8	70	54.3	83	45.8	15.8 (2.3–46.0)	⇡*
	Carbapenem (imipenem/meropenem) resistance	71	25.4	90	25.6	107	25.2	70	42.9	83	32.5	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	71	28.2	90	30.0	107	29.9	70	52.9	83	31.3	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	71	28.2	90	24.4	107	31.8	50	32.0	83	25.3	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	69	27.5	89	25.8	107	30.8	50	50.0	83	31.3	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	92	80.4	110	74.5	132	72.0	129	82.9	217	77.9	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	92	95.7	110	78.2	132	74.2	129	82.9	217	80.2	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	92	89.1	110	73.6	132	78.0	129	76.0	217	81.6	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	92	78.3	110	66.4	132	69.7	129	72.9	217	71.9	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	227	13.7	313	17.6	324	14.8	220	11.8	211	15.2	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	29	27.6[h]	42	9.5	46	8.7	28	7.1[h]	11	NA	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	29	27.6[h]	42	16.7	46	30.4	28	10.7[h]	11	NA	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	29	17.2[h]	42	2.4	46	8.7	28	3.6[h]	11	NA	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	133	43.6	150	39.3	150	37.3	165	47.9	190	48.4	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	84	19.0	91	9.9	99	12.1	77	7.8	148	10.1	17.2 (0.0–66.4)	–

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ⇡ and ⇣ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Croatia

Participating institutions

Reference Center for Antimicrobial Resistance Surveillance
Ministry of Health Zagreb University Hospital for Infectious Diseases (Dr. Fran Mihaljević)

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Croatia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	80	80	ND	80	100
Geographical representativeness	High	High	ND	High	High
Hospital representativeness	ND	High	ND	High	High
Isolate representativeness	ND	High	ND	High	High
Blood culture sets/1 000 patient days	ND	ND	ND	109.0	38.3

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Croatia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	94	100	100	NA	87

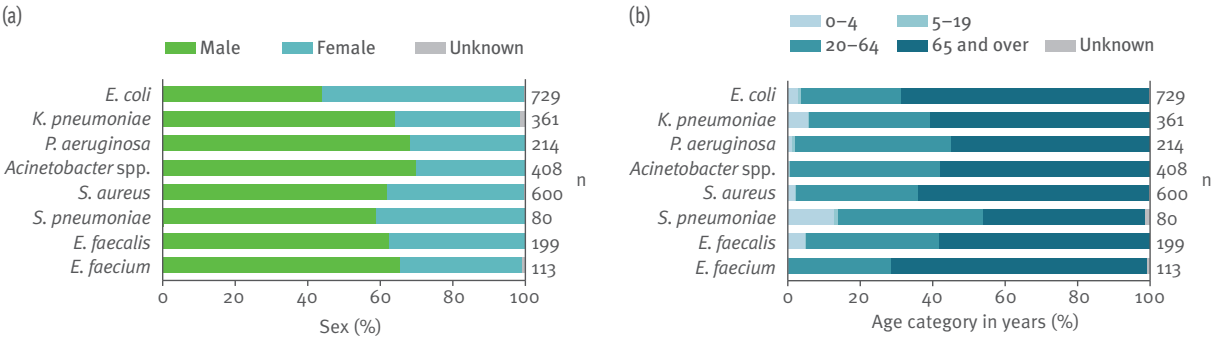
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Croatia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	19	1160	6	19	1216	5	19	1123	8	19	828	7	19	729	12
K. pneumoniae	19	313	18	19	332	14	17	328	14	16	270	20	18	361	32
P. aeruginosa	17	238	17	17	200	16	15	185	15	18	165	32	15	214	45
Acinetobacter spp.	17	208	42	14	155	26	16	143	31	14	225	73	18	408	75
S. aureus	18	520	16	18	458	11	15	360	11	19	424	16	18	600	30
S. pneumoniae	16	130	13	17	146	9	16	156	20	12	55	17	14	80	23
E. faecalis	17	171	11	16	145	12	14	127	16	16	162	23	17	199	38
E. faecium	12	89	12	11	71	13	11	74	19	16	88	28	14	113	50

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Croatia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Croatia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	1135	58.8	1214	57.7	1108	57.1	827	57.7	728	55.8	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1148	16.5	1168	14.8	1085	15.9	827	16.6	726	18.6	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	1132	0.0	1190	0.0	1090	0.2	820	0.0	686	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1150	28.2	1199	30.0	1108	27.3	826	29.7	721	29.0	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1154	16.6	1210	14.9	1112	14.8	828	14.9	725	11.7	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1133	9.4	1150	9.2	1064	9.2	825	8.7	714	7.3	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	309	41.7	318	44.3	317	53.0	270	52.2	361	62.0	34.3 (3.4–81.4)	↑*
	Carbapenem (imipenem/meropenem) resistance	302	0.0	325	2.2	325	12.0	267	19.1	353	32.9	11.7 (0.0–73.7)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	309	40.8	327	48.6	318	57.9	268	54.1	360	63.9	33.6 (0.0–80.0)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	311	30.9	330	36.4	325	42.8	270	38.1	356	46.6	23.7 (0.0–69.1)	↑*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	305	23.0	312	28.2	312	38.1	268	35.8	355	43.4	21.2 (0.0–67.4)	↑*
P. aeruginosa	Piperacillin-tazobactam resistance	234	16.2	196	11.2	182	14.3	164	10.4	209	10.5	18.7 (0.0–47.2)	–
	Ceftazidime resistance	231	19.5	195	17.9	173	20.2	164	18.9	212	17.5	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	238	30.7	199	27.6	183	26.2	165	30.3	214	31.3	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	237	32.9	200	29.0	181	29.8	165	23.0	213	19.7	18.7 (3.3–48.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	237	26.6	199	21.6	183	20.2	ND	ND	ND	ND	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	225	21.8	190	18.4	166	19.3	ND	ND	ND	ND	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	208	96.2	155	95.5	143	92.3	225	96.4	407	99.5	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	204	98.0	155	96.1	142	93.7	224	98.2	405	99.8	43.0 (1.5–99.8)	↑
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	206	84.0	153	91.5	140	92.1	225	96.4	405	98.8	39.6 (2.1–98.8)	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	203	83.7	153	90.8	139	91.4	224	95.1	402	98.5	36.8 (0.0–98.5)	↑*
S. aureus	MRSA[f]	520	28.5	458	26.4	358	24.9	424	29.2	600	34.8	15.8 (0.9–42.9)	↑*
S. pneumoniae	Penicillin non-wild-type[g]	129	22.5	144	18.1	154	20.1	55	23.6	71	18.3	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	127	36.2	143	32.2	154	29.9	55	40.0	79	22.8	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	126	15.9	141	11.3	152	13.8	55	16.4	70	15.7	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	171	33.3	143	33.6	125	24.0	161	37.9	195	39.5	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	89	19.1	71	25.4	74	25.7	88	33.0	113	39.8	17.2 (0.0–66.4)	↑*

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Cyprus

Participating institutions

Microbiology Department, Nicosia General Hospital

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Cyprus, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	85	85	35	75	75
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	44.9	51.1	56.9	60.9	73.8

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Cyprus, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	20	20	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	100	NA	100

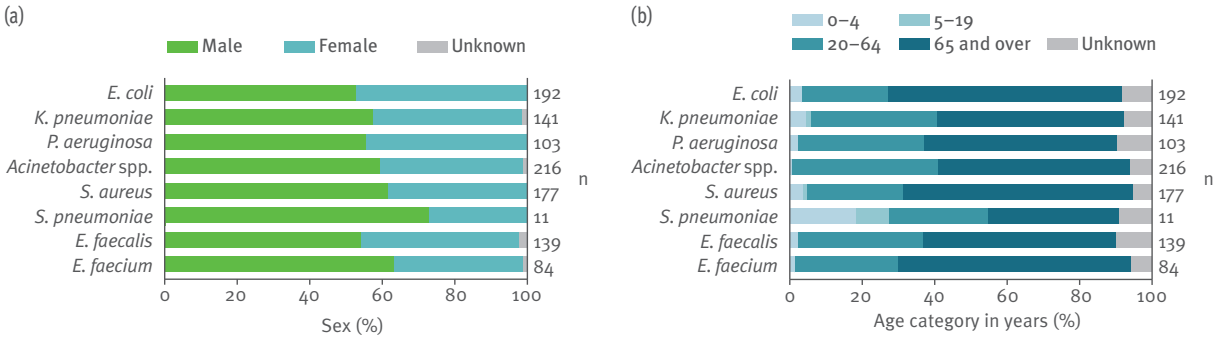
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Cyprus, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	5	156	15	4	151	19	1	92	NA	4	114	9	4	192	13
K. pneumoniae	5	71	33	4	87	33	1	60	NA	4	86	29	4	141	35
P. aeruginosa	4	53	33	4	55	39	1	33	25	4	64	37	4	103	42
Acinetobacter spp.	5	50	46	3	57	53	1	32	69	4	58	60	3	216	80
S. aureus	5	129	26	4	117	17	1	63	23	4	106	11	4	177	39
S. pneumoniae	4	19	NA	3	16	NA	1	8	NA	3	5	NA	4	11	NA
E. faecalis	5	70	30	4	87	34	1	37	20	4	75	41	4	139	57
E. faecium	5	41	26	4	45	37	1	32	38	3	43	32	4	84	46

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Cyprus, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Cyprus, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	156	65.4	151	64.9	92	71.7	114	67.5	191	70.2	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	156	30.8	151	37.1	92	20.7	114	29.8	192	32.8	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	156	1.3	150	2.0	92	0.0	114	0.0	192	1.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	156	42.9	151	42.4	92	43.5	114	48.2	192	51.6	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	156	21.8	151	19.9	92	10.9	114	21.1	192	19.8	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	156	15.4	151	14.6	92	6.5	114	13.2	192	10.9	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	71	46.5	87	48.3	60	48.3	86	54.7	141	54.6	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	71	15.5	87	21.8	60	13.3	86	19.8	141	26.2	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	71	35.2	87	49.4	60	31.7	86	50.0	141	49.6	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	71	26.8	87	36.8	58	24.1	85	22.4	136	36.8	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	71	25.4	87	32.2	58	20.7	85	17.6	136	35.3	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	53	15.1	55	21.8	33	21.2	63	22.2	102	14.7	18.7 (0.0–47.2)	–
	Ceftazidime resistance	53	13.2	55	16.4	33	18.2	63	17.5	102	12.7	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	53	17.0	55	12.7	33	21.2	63	20.6	102	24.5	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	53	5.7	55	25.5	33	12.1	63	20.6	103	17.5	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	53	1.9	55	7.3	33	3.0	49	6.1	69	1.4	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	53	9.4	55	16.4	33	12.1	49	12.2	69	11.6	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	50	76.0	57	84.2	32	87.5	58	81.0	216	92.1	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	50	76.0	55	89.1	32	90.6	58	82.8	216	91.7	43.0 (1.5–99.8)	↑
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	50	76.0	57	75.4	32	84.4	58	77.6	214	89.7	39.6 (2.1–98.8)	↑
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	50	76.0	55	78.2	32	81.3	58	75.9	214	88.8	36.8 (0.0–98.5)	↑
S. aureus	MRSA[f]	125	31.2	117	40.2	58	36.2	106	49.1	177	42.9	15.8 (0.9–42.9)	↑
S. pneumoniae	Penicillin non-wild-type[g]	11	NA	16	NA	2	NA	5	NA	11	NA	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	19	NA	14	NA	8	NA	5	NA	11	NA	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	11	NA	14	NA	2	NA	5	NA	11	NA	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	70	8.6	87	12.6	37	0.0	75	4.0	138	8.0	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	41	43.9	44	59.1	32	50.0	43	44.2	84	51.2	17.2 (0.0–66.4)	–

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Czechia

Participating institutions

National Institute of Public Health
National Reference Laboratory for Antibiotics

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Czechia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	85	81	81	80	80
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	18.0	17.0	16.8	19.7	21.3

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Czechia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	98	100	NA	88

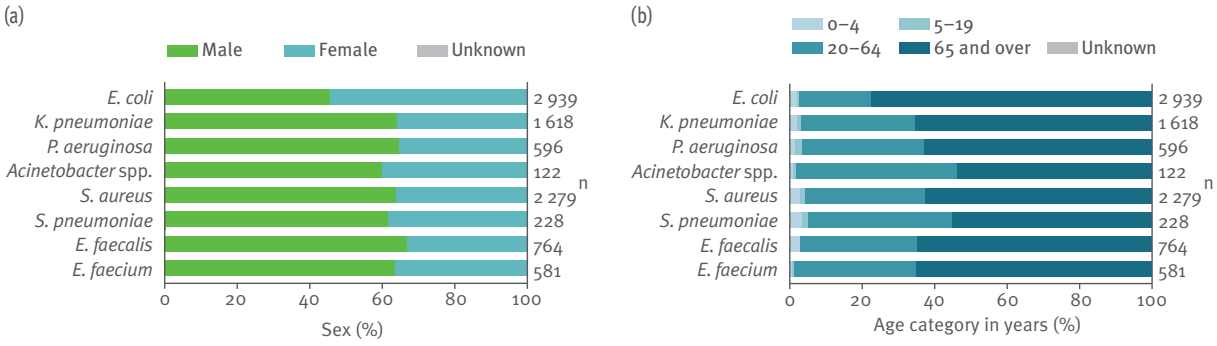
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Czechia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	43	3201	18	48	3650	19	47	3565	16	48	3005	14	40	2939	16
K. pneumoniae	46	1330	29	48	1485	31	48	1563	27	48	1476	30	43	1618	33
P. aeruginosa	44	411	37	47	539	36	47	595	32	48	559	37	43	596	37
Acinetobacter spp.	17	55	31	21	91	32	20	95	48	20	82	44	21	122	52
S. aureus	47	1944	24	48	2244	24	49	2108	23	48	2090	24	44	2279	26
S. pneumoniae	46	366	26	47	378	26	49	387	27	43	204	32	46	228	23
E. faecalis	41	529	33	44	594	35	43	528	30	44	584	35	40	764	37
E. faecium	39	264	38	41	358	37	39	350	38	44	413	36	40	581	46

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Czechia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Czechia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	3198	53.0	3640	54.2	3556	54.6	2997	52.7	2934	51.4	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	3199	14.2	3641	15.2	3557	15.9	2997	13.3	2934	14.4	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	1431	0.0	1752	0.1	1689	0.0	1500	0.1	1342	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	3199	24.5	3638	24.3	3554	23.0	2997	20.2	2934	19.7	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	3199	10.7	3643	9.5	3559	11.4	2999	10.2	2935	9.6	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	3199	6.3	3638	6.3	3554	6.6	2995	5.4	2934	5.6	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1329	53.2	1482	50.1	1563	50.7	1474	45.9	1618	49.7	34.3 (3.4–81.4)	↓*
	Carbapenem (imipenem/meropenem) resistance	1051	0.4	1194	0.3	1314	0.6	1232	0.5	1348	1.0	11.7 (0.0–73.7)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1329	49.2	1482	47.2	1562	48.7	1474	44.2	1618	42.8	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1330	49.6	1483	48.6	1563	47.7	1474	42.5	1618	41.6	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1329	41.8	1482	38.7	1562	39.3	1473	34.6	1618	33.9	21.2 (0.0–67.4)	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	405	20.7	531	22.6	584	23.6	550	20.4	590	21.5	18.7 (0.0–47.2)	–
	Ceftazidime resistance	411	13.4	539	20.4	594	22.7	559	19.0	596	19.3	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	411	14.8	539	18.0	595	14.5	559	15.7	595	16.3	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	411	30.2	539	33.4	594	33.7	559	28.4	596	26.7	18.7 (3.3–48.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	411	14.4	539	19.3	594	21.7	559	13.2	596	12.6	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	405	16.5	531	21.7	584	19.0	550	15.5	589	15.4	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	55	12.7	91	19.8	95	30.5	82	32.9	122	53.3	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	55	20.0	91	24.2	95	32.6	82	35.4	122	53.3	43.0 (1.5–99.8)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	55	12.7	91	22.0	95	33.7	82	34.1	122	50.8	39.6 (2.1–98.8)	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	55	5.5	91	18.7	95	29.5	82	30.5	122	50.8	36.8 (0.0–98.5)	↑*
S. aureus	MRSA[f]	1944	14.1	2243	13.7	2108	12.5	2089	9.3	2279	9.4	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	366	4.9	378	5.0	387	4.9	204	4.4	228	5.7	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	366	9.0	378	10.1	387	10.3	204	6.9	228	10.5	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	366	3.0	378	2.6	387	2.3	204	2.0	228	3.5	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	526	34.0	594	33.7	527	31.5	583	30.2	762	38.5	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	264	13.3	358	20.7	349	19.8	410	16.6	578	12.6	17.2 (0.0–66.4)	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Denmark

Participating institutions

Statens Serum Institut
Danish Study Group for Antimicrobial Resistance Surveillance (DANRES)

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Denmark, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	100	100	100
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	138.5	171.2	191.7	236.4	251.0

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Denmark, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	91	82	100	NA	100

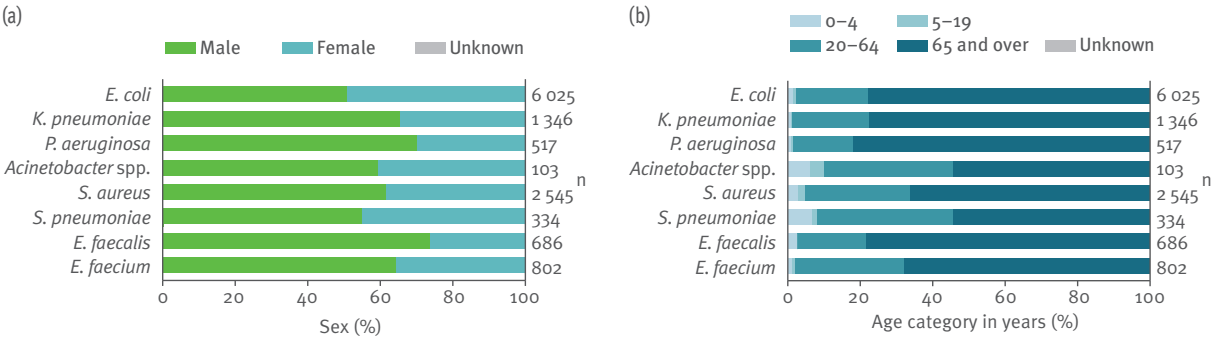
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Denmark, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	10	5123	2	10	5398	8	10	5613	2	10	5878	3	10	6025	3
K. pneumoniae	10	1186	3	10	1280	7	10	1361	3	10	1415	4	10	1346	4
P. aeruginosa	10	484	6	10	489	9	10	493	5	10	505	4	10	517	5
Acinetobacter spp.	9	68	5	8	55	8	9	72	6	9	66	6	10	103	11
S. aureus	10	1996	NA	10	2181	NA	10	2172	NA	10	2390	5	10	2545	5
S. pneumoniae	10	727	NA	10	760	NA	10	601	2	10	351	NA	10	334	NA
E. faecalis	10	674	6	10	606	8	10	632	5	10	651	7	10	686	6
E. faecium	10	786	30	10	782	28	10	737	23	10	795	21	10	802	28

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Denmark, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Denmark, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	4885	45.6	5383	46.0	5593	46.3	5864	44.1	6001	41.5	53.1 (31.7–70.2)	⇣*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	4883	6.9	4833	7.7	5091	7.5	5286	6.7	5416	6.2	13.8 (5.5–37.3)	⇣*
	Carbapenem (imipenem/meropenem) resistance	5117	0.0	4640	0.0	5577	0.1	5840	0.2	5845	0.1	0.2 (0.0–1.1)	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	5123	12.8	5386	13.3	5605	11.5	5870	11.2	6016	10.5	21.9 (9.6–51.6)	⇣*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	5122	6.0	5393	5.7	5599	5.5	5870	5.5	6017	4.4	9.6 (4.1–27.0)	⇣*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	4883	1.8	4829	2.0	5084	1.9	5277	1.6	5409	1.2	5.1 (1.2–14.8)	⇣*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1125	7.3	1159	6.5	1248	6.7	1264	6.0	1228	5.1	34.3 (3.4–81.4)	⇣*
	Carbapenem (imipenem/meropenem) resistance	1185	0.3	1109	0.5	1356	0.3	1413	0.8	1324	0.5	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1183	9.1	1279	8.5	1361	9.6	1414	7.6	1346	7.1	33.6 (0.0–80.0)	⇣*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1186	3.2	1278	3.3	1358	3.5	1412	3.3	1344	2.1	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1122	2.4	1159	1.9	1245	2.3	1261	1.7	1228	1.1	21.2 (0.0–67.4)	⇣*
P. aeruginosa	Piperacillin-tazobactam resistance	484	2.9	489	2.9	493	4.1	505	4.4	517	5.0	18.7 (0.0–47.2)	⇡*
	Ceftazidime resistance	461	3.5	458	3.3	471	4.0	471	3.2	482	2.3	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	484	2.5	422	5.2	491	3.3	503	4.4	514	3.5	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	484	5.0	489	4.3	493	5.5	505	3.2	517	3.3	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	484	1.0	489	0.6	490	2.7	61	0.0	226	0.0	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	461	0.4	391	1.3	469	1.7	61	3.3	225	1.3	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	66	0.0	47	6.4	72	0.0	64	4.7	102	5.9	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	68	1.5	55	9.1	72	6.9	65	13.8	103	15.5	43.0 (1.5–99.8)	⇡*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	68	0.0	53	7.5	72	2.8	65	4.6	100	7.0	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	66	0.0	46	4.3	72	0.0	63	4.8	99	6.1	36.8 (0.0–98.5)	⇡*
S. aureus	MRSA[f]	1996	2.5	2181	1.7	2172	2.2	2390	1.7	2545	1.8	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	727	3.9	760	5.5	601	5.0	351	6.8	334	9.6	16.3 (3.6–35.7)	⇡*
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	727	3.6	760	2.5	601	3.5	351	3.7	334	5.1	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	727	1.8	760	1.3	601	1.3	351	2.3	334	3.0	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	56	7.1	171	12.3	47	8.5	187	11.8	ND	ND	29.0 (6.7–55.2)	NA
E. faecium	Vancomycin resistance	785	7.0	779	12.5	734	9.8	793	9.6	800	10.6	17.2 (0.0–66.4)	–

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ⇡ and ⇣ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Estonia

Participating institutions

Estonian Health Board
East-Tallinn Central Hospital
Tartu University Hospital

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Estonia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	100	100	100
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	34.1	31.9	33.4	35.8	39.2

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Estonia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	100	NA	91

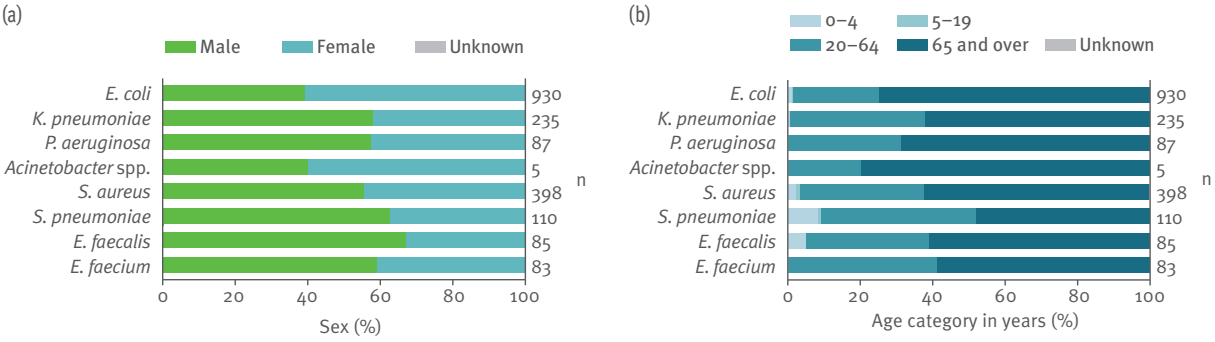
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Estonia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	10	788	9	10	850	7	9	910	8	9	979	7	9	930	6
K. pneumoniae	10	161	20	9	206	17	9	179	18	9	199	13	9	235	14
P. aeruginosa	9	57	39	7	48	19	8	70	13	9	79	20	9	87	23
Acinetobacter spp.	9	16	NA	7	14	NA	5	16	NA	4	12	NA	3	5	NA
S. aureus	10	290	8	9	360	8	9	366	11	9	367	11	9	398	8
S. pneumoniae	11	141	10	9	142	10	9	161	8	9	80	8	9	110	7
E. faecalis	10	71	23	8	88	20	9	93	18	9	108	19	7	85	9
E. faecium	10	52	37	7	64	36	7	74	43	8	61	16	6	83	35

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Estonia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Estonia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	439	47.8	457	43.5	499	42.1	422	45.7	338	41.1	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	788	8.8	850	9.8	910	11.5	979	8.3	929	8.1	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	687	0.0	758	0.0	800	0.0	861	0.0	826	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	781	17.4	829	17.6	897	17.1	959	14.1	922	13.4	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	786	5.7	849	6.2	907	5.3	968	5.5	926	5.5	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	780	3.7	828	3.0	894	2.1	948	1.6	917	2.1	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	161	21.1	206	13.6	179	10.6	199	11.6	235	12.8	34.3 (3.4–81.4)	↓*
	Carbapenem (imipenem/meropenem) resistance	143	0.0	179	0.6	152	0.0	173	0.0	218	0.9	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	161	24.8	205	21.0	179	16.2	197	17.3	235	16.6	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	161	12.4	205	10.2	179	6.1	197	8.1	235	7.7	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	161	11.8	204	8.8	179	5.6	196	7.1	235	5.5	21.2 (0.0–67.4)	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	55	14.5	48	8.3	70	7.1	77	9.1	87	6.9	18.7 (0.0–47.2)	–
	Ceftazidime resistance	47	8.5	47	4.3	66	4.5	77	6.5	83	3.6	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	55	9.1	48	16.7	69	5.8	79	12.7	87	14.9	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	56	12.5	45	13.3	68	5.9	76	10.5	84	16.7	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	56	5.4	48	4.2	67	3.0	1	NA	9	NA	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	42	9.5	44	4.5	62	3.2	ND	ND	5	NA	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	15	NA	14	NA	16	NA	11	NA	5	NA	39.9 (0.0–99.5)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	11	NA	11	NA	10	NA	7	NA	2	NA	43.0 (1.5–99.8)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	9	NA	11	NA	8	NA	5	NA	2	NA	39.6 (2.1–98.8)	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	9	NA	11	NA	8	NA	5	NA	2	NA	36.8 (0.0–98.5)	NA
S. aureus	MRSA[f]	290	2.1	359	3.3	366	3.0	367	3.0	398	1.5	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	141	2.1	142	2.8	161	4.3	79	5.1	109	4.6	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	127	3.9	136	7.4	158	7.0	76	9.2	98	6.1	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	127	1.6	136	2.2	158	2.5	75	2.7	97	4.1	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	71	19.7	87	25.3	93	12.9	107	15.0	73	11.0	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	52	5.8	64	6.3	74	4.1	61	3.3	83	7.2	17.2 (0.0–66.4)	–

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Finland

Participating institutions

Finnish Institute for Health and Welfare
Finnish Study Group for Antimicrobial Resistance (FiRe)
Finnish Hospital Infection Program (SIRO)

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Finland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	96	96	96
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	154.9	150.1	160.4	175.1	143.9

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report Antimicrobial resistance surveillance in Europe 2022–2020 data.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Finland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	94	94	89	NA	88

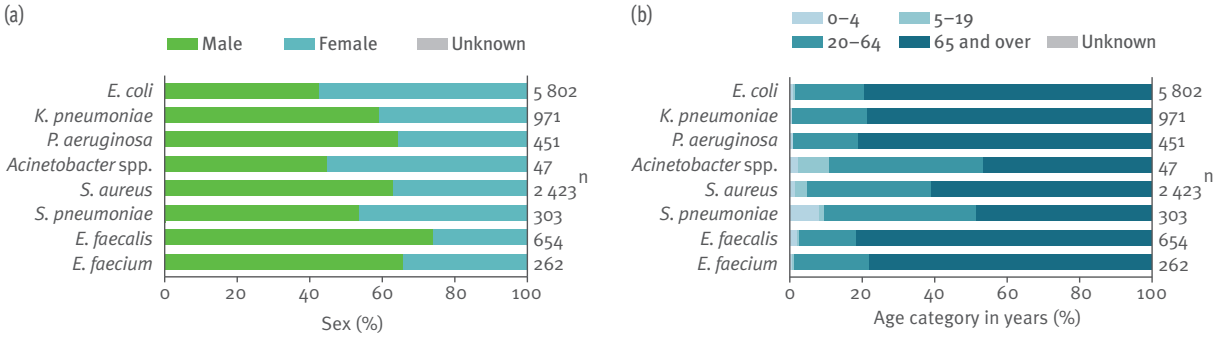
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Finland, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	20	5315	NA	19	5057	NA	19	5418	NA	18	5375	NA	19	5802	NA
K. pneumoniae	20	758	NA	19	810	NA	18	869	NA	17	901	NA	19	971	NA
P. aeruginosa	20	378	NA	19	391	NA	19	470	NA	17	433	NA	19	451	NA
Acinetobacter spp.	11	37	NA	14	28	NA[c]	16	43	NA	12	37	NA	14	47	NA
S. aureus	20	2439	NA	18	2105	NA	19	2473	NA	18	2188	NA	19	2423	NA
S. pneumoniae	20	835	NA	19	662	NA	18	678	NA	18	293	NA	17	303	NA
E. faecalis	20	549	NA	19	528	NA	19	592	NA	18	566	NA	19	654	NA
E. faecium	20	301	NA	19	290	NA	19	291	NA	18	259	NA	18	262	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Finland, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Finland, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	2874	35.2	3129	35.3	3000	35.5	2928	34.1	3177	31.7	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	5223	6.9	5020	7.6	5413	7.9	5367	7.2	5799	6.6	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	5315	0.0	5057	0.0	5331	0.0	5375	0.0	5801	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	5305	12.0	5043	11.5	5410	11.4	5354	10.5	5802	9.6	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	4982	5.0	4815	4.3	5159	4.8	5373	5.7	5802	4.1	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	4971	2.4	4798	2.0	5151	2.3	5346	1.9	5799	1.8	5.1 (1.2–14.8)	↓
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	744	4.6	805	4.5	868	6.3	901	7.2	971	5.6	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	758	0.3	810	0.6	850	0.4	901	0.1	971	0.0	11.7 (0.0–73.7)	↓
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	756	7.9	808	6.3	865	7.3	893	7.4	971	5.5	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	721	2.9	774	2.6	831	4.2	901	5.8	971	4.2	23.7 (0.0–69.1)	↑*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	716	2.4	771	1.6	827	3.1	893	3.5	971	2.2	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	377	6.4	391	6.6	457	6.6	433	5.5	450	4.7	18.7 (0.0–47.2)	–
	Ceftazidime resistance	378	6.1	390	4.4	463	4.5	433	5.3	451	4.9	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	377	6.1	391	4.9	462	6.3	433	3.7	451	4.2	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	356	11.5	376	12.8	468	8.5	431	10.2	451	9.8	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	378	1.9	391	1.0	458	0.7	433	1.4	451	0.9	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	354	3.7	376	1.9	455	2.4	431	3.5	450	1.6	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	37	2.7	28	0.0[h]	43	0.0	37	5.4	47	2.1	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	37	2.7	28	0.0[h]	43	0.0	36	8.3	47	2.1	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	36	0.0	27	7.4[h]	42	0.0	37	2.7	47	2.1	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	36	0.0	27	0.0[h]	42	0.0	36	2.8	47	2.1	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	2439	2.1	2105	2.1	2473	2.3	2188	2.6	2423	2.6	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	698	10.5	600	11.5	594	12.0	252	11.5	247	14.6	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	808	15.0	653	12.1	655	10.5	288	11.8	301	13.3	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	671	6.7	591	5.8	571	6.3	247	7.3	245	8.6	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	29.0 (6.7–55.2)	NA
E. faecium	Vancomycin resistance	301	0.7	289	1.7	291	0.0	259	0.4	261	0.4	17.2 (0.0–66.4)	–

ND: no data available.
NA: not applicable.
[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.
[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

France

Participating institutions

Santé Publique France
Since 2020: Surveillance and Prevention of Antimicrobial RESistance in hospital settings (SPARES)
National Reference Centre for Pneumococci (CNRP)
Up to 2019: French National Observatory for the Epidemiology of Bacterial Resistance to Antimicrobials (ONERBA) through three participating networks: Azay-Résistance, Île-de-France, Réussir

Population and hospitals contributing data: coverage, representativeness and blood culture rate, France, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)[a]					
Laboratories collecting *S. pneumoniae* (CNRP)	58[b]	61	56	38	56
Laboratories collecting other species (SPARES network since 2020[c])	22	21	20	48	55
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days[d]	88.1	105.2	112.2	54.5	54.6

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.
[a] Calculation based on proportion of hospital days in participating hospitals out of total hospital days in the country.
[b] Restricted to first half of the year.
[c] ONERBA laboratories up to 2019.
[d] Calculated excluding laboratories collecting *S. pneumoniae*.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, France, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	87	71	86	NA	ND

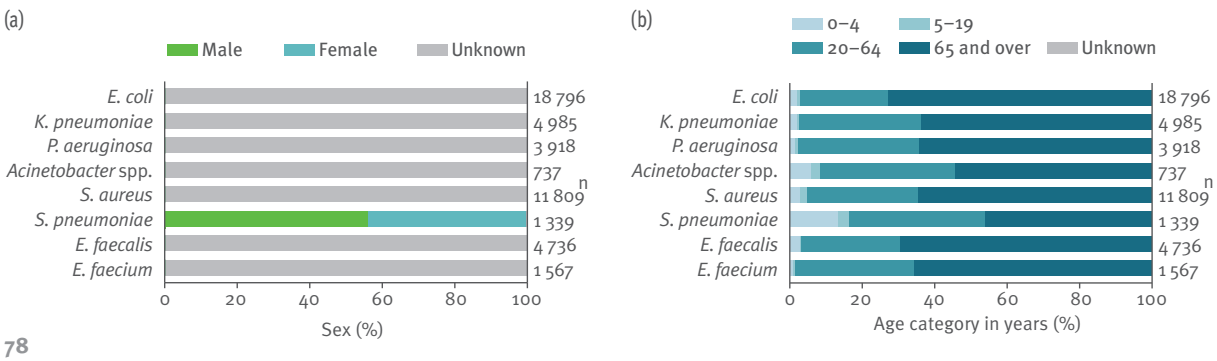
ND: no data available.
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, France, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	54	13392	8	49	12645	8	46	13536	8	779	18939	8	743	18796	8
K. pneumoniae	54	2904	16	49	3043	17	46	3170	15	558	5078	16	545	4985	17
P. aeruginosa	36	1721	22	34	1902	25	45	2200	21	490	3656	26	489	3918	26
Acinetobacter spp.	52	475	17	47	498	11	45	515	17	241	710	10	219	737	11
S. aureus	54	6668	16	49	7097	15	46	6723	14	672	10967	12	661	11809	13
S. pneumoniae	169	614	NA	143	1045	NA	193	1264	NA	127	668	NA	194	1339	NA
E. faecalis	53	2259	20	48	2300	20	46	2526	19	508	4456	21	511	4736	22
E. faecium	53	1000	27	49	1001	27	46	1080	24	295	1428	28	311	1567	27

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, France, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, France, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	13293	55.6	12553	55.6	13415	54.5	17674	53.9	17706	52.3	53.1 (31.7–70.2)	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	13352	10.2	12614	9.6	13019	8.8	18857	9.5	18735	8.3	13.8 (5.5–37.3)	NA
	Carbapenem (imipenem/meropenem) resistance	12843	0.0	12399	0.0	12636	0.0	17838	0.0	17546	0.1	0.2 (0.0–1.1)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	13328	15.0	12443	16.3	13431	16.0	18569	15.9	18446	14.8	21.9 (9.6–51.6)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	13103	7.0	12283	7.4	13133	7.0	17786	6.7	17653	5.8	9.6 (4.1–27.0)	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	13038	3.0	12107	3.5	12639	3.0	17433	2.9	17301	2.6	5.1 (1.2–14.8)	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	2892	28.8	3033	30.8	3075	30.2	5045	27.8	4973	25.4	34.3 (3.4–81.4)	NA
	Carbapenem (imipenem/meropenem) resistance	2807	0.7	2998	0.5	3003	1.0	4796	0.5	4727	0.8	11.7 (0.0–73.7)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	2886	26.8	2997	30.4	3143	30.9	5001	28.1	4889	25.0	33.6 (0.0–80.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	2857	23.8	2990	24.8	3103	23.4	4767	18.8	4706	17.4	23.7 (0.0–69.1)	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	2844	19.4	2948	21.5	3004	19.8	4692	16.4	4617	14.9	21.2 (0.0–67.4)	NA
P. aeruginosa	Piperacillin-tazobactam resistance	1684	16.7	1850	17.4	1879	16.7	3417	17.1	3580	17.0	18.7 (0.0–47.2)	NA
	Ceftazidime resistance	1568	12.2	1892	13.0	1999	11.5	3574	12.8	3754	12.5	15.8 (2.3–46.0)	NA
	Carbapenem (imipenem/meropenem) resistance	1710	13.9	1896	16.0	2076	12.7	3583	12.6	3850	12.1	18.1 (3.5–45.9)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1709	15.1	1893	15.1	2074	13.7	3585	14.8	3785	14.1	18.7 (3.3–48.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	1713	10.9	1898	9.3	2086	7.8	3059	5.6	3297	4.9	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	1556	10.6	1844	10.6	1759	8.6	2896	8.9	3044	8.2	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	469	6.2	490	6.5	487	9.0	692	3.3	720	3.1	39.9 (0.0–99.5)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	473	12.3	491	12.0	481	13.3	653	9.0	672	7.1	43.0 (1.5–99.8)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	474	9.1	482	8.9	473	14.6	661	8.3	673	6.1	39.6 (2.1–98.8)	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	468	5.3	470	5.5	458	8.5	628	1.9	626	2.4	36.8 (0.0–98.5)	NA
S. aureus	MRSA[f]	6472	12.9	6903	12.1	6467	11.6	10763	12.1	11536	11.0	15.8 (0.9–42.9)	NA
S. pneumoniae	Penicillin non-wild-type[g]	614	25.9	1045	29.1	1264	25.3	668	32.3	1339	32.0	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	614	23.1	1045	23.9	1264	19.4	668	21.6	1339	23.0	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	614	17.6	1045	20.4	1264	16.1	668	18.4	1339	20.3	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	795	12.7	1568	9.8	1346	12.0	ND	ND	ND	ND	29.0 (6.7–55.2)	NA
E. faecium	Vancomycin resistance	986	0.8	987	0.6	1062	0.7	1385	0.6	1517	0.5	17.2 (0.0–66.4)	NA

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Georgia

Participating institutions

Lugar Center for Public Health Research, National Center for Disease Control and Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Georgia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	60	60	80	80	80
Geographical representativeness	High	High	Medium	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Low	Low	Low	Low	Low
Blood culture sets/1 000 patient days[a]	ND	11 (4–66)	6 (2–13)	5 (0–33)	14 (0–204)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Georgia, 2017–2021

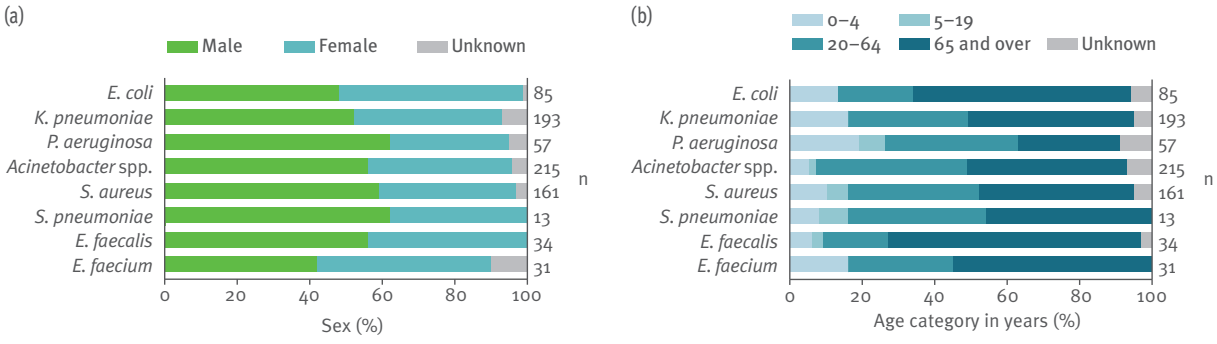
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	40	50	60	60	68
Percentage of laboratories participating in CAESAR EQA	100	100	100	100	93

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Georgia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	5	27	NA	11	56	70	6	80	NA	13	133	NA	9	85	93
K. pneumoniae	6	58	NA	11	81	76	7	162	NA	16	205	NA	12	193	96
P. aeruginosa	5	16	NA	10	23	73[c]	8	64	78	9	56	NA	9	57	93
Acinetobacter spp.	6	35	NA	12	45	83	8	91	81	17	163	NA	13	215	NA
S. aureus	6	38	NA	12	67	55	8	144	74	16	180	NA	11	161	97
S. pneumoniae	2	3	NA	3	3	NA	4	8	NA	2	7	NA	2	13	NA
E. faecalis	4	21	NA	5	12	NA	6	16	NA	9	42	NA	5	34	92
E. faecium	3	3	NA	3	4	NA	1	2	NA	3	9	NA	5	31	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Georgia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Georgia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	6	NA	18	NA	77	74.0	116	67.2	70	78.6	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	27	40.7[f]	56	55.4	80	57.5	133	43.6	84	36.9	NA
	Carbapenem (imipenem/meropenem) resistance	27	0.0[f]	56	10.7	80	7.5	133	0.8	85	7.1	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	27	37.0[f]	55	50.9	80	43.8	133	43.6	85	21.2	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	25	32.0[f]	24	45.8[f]	67	16.4	128	10.9	74	13.5	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	25	16.0[f]	24	37.5[f]	67	6.0	128	5.5	73	8.2	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	57	91.2	81	87.7	159	74.8	205	79.0	193	89.6	NA
	Carbapenem (imipenem/meropenem) resistance	57	47.4	81	28.4	162	30.9	205	62.0	193	78.8	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	56	58.9	81	55.6	162	45.7	204	49.5	192	70.3	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	52	65.4	74	48.6	155	40.6	201	54.2	185	55.7	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	50	40.0	74	35.1	152	23.0	200	29.0	184	41.8	NA
P. aeruginosa	Piperacillin-tazobactam resistance	15	NA	20	35.0[f]	57	40.4	53	35.8	55	58.2	NA
	Ceftazidime resistance	15	NA	23	69.6[f]	50	50.0	50	42.0	53	60.4	NA
	Carbapenem (imipenem/meropenem) resistance	16	NA	23	43.5[f]	61	52.5	56	35.7	57	59.6	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	16	NA	23	47.8[f]	59	47.5	56	33.9	57	50.9	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	14	NA	22	54.5[f]	53	45.3	43	34.9	50	44.0	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	12	NA	20	45.0[f]	43	55.8	43	34.9	47	53.2	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	34	85.3	45	88.9	91	73.6	163	68.7	215	90.2	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	34	88.2	45	97.8	82	80.5	158	74.7	214	90.7	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	34	67.6	45	77.8	91	38.5	160	58.7	212	65.1	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	33	57.6	45	71.1	82	30.5	155	47.1	211	63.5	NA
S. aureus	MRSA[d]	35	11.4	53	15.1	112	16.1	179	16.2	159	25.8	NA
S. pneumoniae	Penicillin non-wild-type[e]	2	NA	3	NA	5	NA	6	NA	13	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	3	NA	3	NA	7	NA	6	NA	9	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	2	NA	3	NA	5	NA	5	NA	9	NA	NA
E. faecalis	High-level gentamicin resistance	18	NA	5	NA	9	NA	38	60.5	33	48.5	NA
E. faecium	Vancomycin resistance	3	NA	4	NA	2	NA	9	NA	31	25.8	NA

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Germany

Participating institutions

Robert Koch Institute

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Germany, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	30	27	27	33	35
Geographical representativeness	High	High	High	High	High
Hospital representativeness	Medium	Medium	Medium	Medium	Medium
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	27.2	30.8	37.9	ND	ND

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Germany, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	81	86	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	91	91	95	NA	97

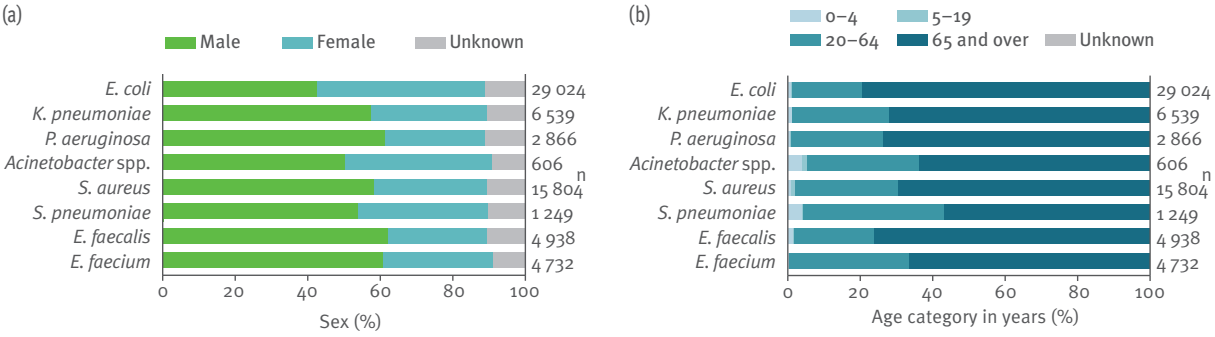
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Germany, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	56	22945	14	48	21994	15	47	23415	15	52	28462	15	56	29024	15
K. pneumoniae	55	3857	21	48	3974	22	47	4721	24	52	5994	24	56	6539	25
P. aeruginosa	55	1896	26	47	1792	26	46	2108	27	52	2662	25	55	2866	29
Acinetobacter spp.	50	543	17	45	529	15	46	467	15	50	609	21	53	606	19
S. aureus	56	13141	21	48	11924	21	47	11958	23	52	14431	23	56	15804	23
S. pneumoniae	54	2049	22	48	1916	24	46	2035	24	52	1357	27	54	1249	27
E. faecalis	56	4002	24	48	3638	23	47	3770	25	52	4630	24	56	4938	25
E. faecium	56	2648	40	47	2464	43	47	2801	48	52	3918	47	55	4732	49

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Germany, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Germany, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	21646	48.9	20841	49.2	23324	48.7	28227	47.6	28500	45.6	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	22929	12.3	21989	12.2	23413	11.5	28461	10.4	29021	9.1	13.8 (5.5–37.3)	↓*
	Carbapenem (imipenem/meropenem) resistance	22940	0.0	21957	0.0	23391	0.0	28458	0.0	29015	0.0	0.2 (0.0–1.1)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	22940	20.7	21958	19.8	23374	17.5	28446	16.5	28997	14.7	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	22478	7.0	21634	6.9	22990	8.3	27124	7.5	27447	5.6	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	22464	3.7	21630	3.4	22971	3.1	27110	2.7	27427	2.2	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	3854	14.6	3973	12.9	4719	12.2	5988	10.9	6538	10.4	34.3 (3.4–81.4)	↓*
	Carbapenem (imipenem/meropenem) resistance	3857	0.5	3968	0.4	4718	0.9	5991	0.5	6538	0.8	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	3857	15.3	3970	13.4	4715	13.1	5991	11.7	6422	10.9	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	3776	8.2	3918	6.2	4654	7.3	5746	5.6	6217	4.3	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	3774	6.3	3918	4.7	4649	4.8	5740	3.7	6099	2.7	21.2 (0.0–67.4)	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	1856	12.6	1765	12.4	2077	11.7	2641	11.7	2842	13.3	18.7 (0.0–47.2)	–
	Ceftazidime resistance	1883	9.8	1784	9.1	2104	10.0	2660	9.9	2861	10.6	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	1892	12.6	1790	12.1	2108	12.9	2662	13.9	2864	14.8	18.1 (3.5–45.9)	↑
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1895	13.9	1789	12.4	2108	13.4	2662	10.6	2865	10.0	18.7 (3.3–48.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	1869	4.8	1788	3.5	2107	4.1	2374	2.0	2600	1.9	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	1817	6.6	1756	5.9	2072	6.3	2351	6.9	2573	6.8	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	540	4.1	527	4.4	462	2.2	607	3.1	605	4.3	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	536	6.5	520	6.7	443	5.0	598	4.8	603	5.6	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	498	3.4	498	3.4	430	4.2	549	4.7	549	4.2	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	495	1.2	498	2.2	425	1.4	548	2.2	546	2.9	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	13128	9.1	11918	7.7	11950	6.7	14427	5.5	15796	4.9	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	1989	4.5	1867	5.2	1962	5.7	1315	6.0	1196	7.8	16.3 (3.6–35.7)	↑*
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	2029	6.9	1883	7.1	1970	7.7	1324	7.2	1188	6.6	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	1969	2.2	1839	2.5	1903	3.0	1282	2.1	1136	2.2	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	2930	25.3	2273	22.9	1561	18.0	2352	16.2	2670	14.5	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	2642	16.5	2458	23.7	2797	26.3	3906	22.3	4721	21.6	17.2 (0.0–66.4)	↑

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Greece

Participating institutions

National Public Health Organization, Central Public Health Laboratory
University of West Attica, Department of Public Health Policy, School of Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Greece, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	68	68	13	30	42
Geographical representativeness	High	High	Medium	High	High
Hospital representativeness	High	High	Medium	High	High
Isolate representativeness	High	Medium	Medium	Medium	Medium
Blood culture sets/1 000 patient days	ND	ND	ND	ND	ND

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Greece, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	13	21	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	89	96	95	NA	85

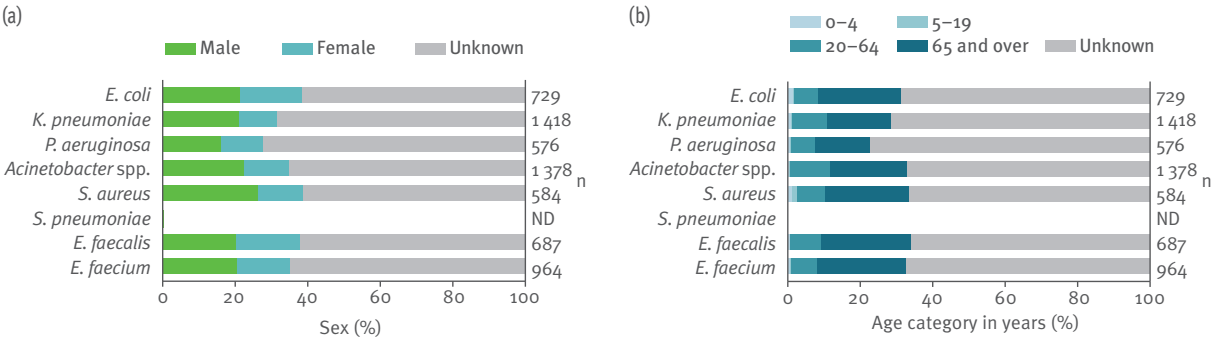
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Greece, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	32	1472	5	37	1642	5	6	204	6	13	567	6	19	729	6
K. pneumoniae	33	1363	38	36	1500	37	6	312	37	12	728	38	19	1418	49
P. aeruginosa	31	821	37	37	859	37	6	141	45	12	390	35	19	576	38
Acinetobacter spp.	32	1096	50	34	1015	48	5	196	45	12	742	47	19	1378	60
S. aureus	33	833	11	36	889	7	5	171	8	13	449	14	19	584	13
S. pneumoniae	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E. faecalis	33	638	25	36	682	28	6	141	26	11	376	28	19	687	38
E. faecium	31	412	26	35	529	25	5	117	32	12	460	39	18	964	47

Labs: laboratories.
ND: no data available.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Greece, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Greece, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	1306	57.5	1444	57.5	154	57.1	452	55.5	557	59.8	53.1 (31.7–70.2)	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1470	18.3	1640	19.3	190	18.9	567	21.9	727	21.7	13.8 (5.5–37.3)	NA
	Carbapenem (imipenem/meropenem) resistance	1467	1.6	1640	1.0	203	1.0	566	0.5	728	1.1	0.2 (0.0–1.1)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1464	32.9	1631	30.8	203	29.6	565	32.7	728	33.9	21.9 (9.6–51.6)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1467	17.0	1633	15.5	201	12.9	562	18.7	719	18.6	9.6 (4.1–27.0)	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1463	9.8	1628	9.8	186	8.6	561	10.5	717	11.9	5.1 (1.2–14.8)	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1362	69.2	1500	70.7	310	66.5	726	74.5	1416	80.4	34.3 (3.4–81.4)	NA
	Carbapenem (imipenem/meropenem) resistance	1363	64.7	1498	63.9	312	58.3	726	66.3	1418	73.7	11.7 (0.0–73.7)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1346	66.9	1488	68.1	311	66.9	726	74.4	1418	80.0	33.6 (0.0–80.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1348	53.2	1487	54.4	310	55.2	718	61.0	1399	69.1	23.7 (0.0–69.1)	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1345	47.9	1487	50.4	307	53.1	714	58.3	1397	67.4	21.2 (0.0–67.4)	NA
P. aeruginosa	Piperacillin-tazobactam resistance	771	23.7	815	21.5	109	34.9	270	35.6	513	36.5	18.7 (0.0–47.2)	NA
	Ceftazidime resistance	814	24.9	853	22.3	136	39.7	344	30.2	529	31.4	15.8 (2.3–46.0)	NA
	Carbapenem (imipenem/meropenem) resistance	821	39.3	856	37.5	141	48.9	378	35.7	576	33.3	18.1 (3.5–45.9)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	816	35.3	856	33.1	141	46.8	333	42.9	576	35.8	18.7 (3.3–48.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	815	30.2	856	26.5	141	42.6	301	28.6	432	28.5	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	769	29.8	814	26.5	107	31.8	171	33.9	378	31.7	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	1095	94.8	1013	92.4	196	92.3	740	94.6	1377	96.9	39.9 (0.0–99.5)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1060	96.0	998	93.5	189	95.8	729	95.7	1371	97.2	43.0 (1.5–99.8)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1064	85.6	1003	81.6	194	88.7	727	90.4	1269	91.4	39.6 (2.1–98.8)	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	1059	84.3	995	81.3	187	91.4	715	90.8	1262	91.4	36.8 (0.0–98.5)	NA
S. aureus	MRSA[f]	822	38.4	888	36.4	170	37.6	448	40.2	583	41.9	15.8 (0.9–42.9)	NA
S. pneumoniae	Penicillin non-wild-type[g]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	621	12.2	668	12.0	128	7.8	298	9.7	517	9.5	29.0 (6.7–55.2)	NA
E. faecium	Vancomycin resistance	412	30.8	527	28.1	117	47.0	445	41.8	950	41.1	17.2 (0.0–66.4)	NA

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period. For Greece, the change comprises the decrease in the number of laboratories reporting data starting with 2019 data, as EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Hungary

Participating institutions

National Public Health Center

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Hungary, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	90	90	90	90
Geographical representativeness	ND	High	High	High	High
Hospital representativeness	ND	High	High	High	High
Isolate representativeness	ND	High	High	High	High
Blood culture sets/1 000 patient days	11.5	12.2	12.3	17.2	22.0

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Hungary, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	97	93	97	NA	100

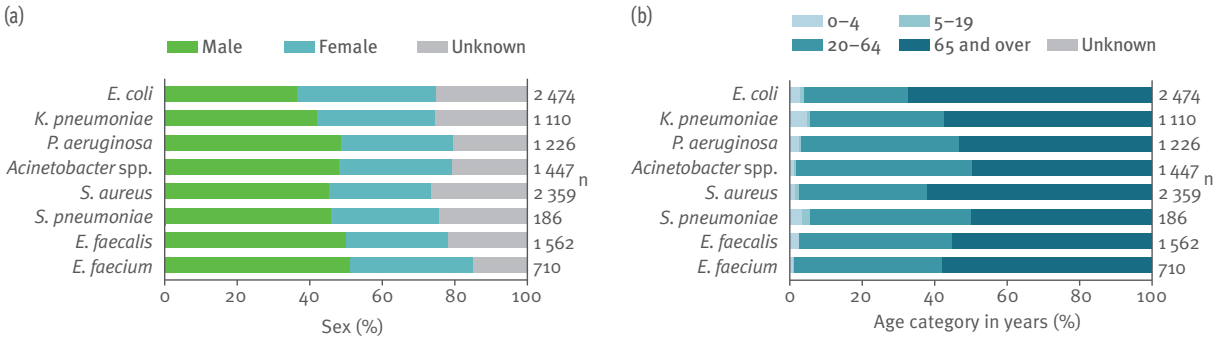
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Hungary, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	31	2061	13	29	2373	11	30	2413	12	29	1963	15	30	2474	16
K. pneumoniae	29	693	28	28	850	24	29	912	26	26	730	32	30	1110	33
P. aeruginosa	30	735	49	29	807	40	30	884	42	26	779	44	30	1226	57
Acinetobacter spp.	31	358	51	26	358	54	27	420	56	24	534	NA	29	1447	74
S. aureus	28	1566	19	27	1721	17	28	1884	16	28	1513	23	29	2359	22
S. pneumoniae	27	204	16	25	207	20	27	222	19	21	124	25	27	186	27
E. faecalis	30	769	38	29	750	36	30	816	37	28	962	49	31	1562	55
E. faecium	27	315	46	29	303	42	27	304	42	27	471	NA	30	710	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Hungary, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Hungary, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	2021	60.3	2312	62.7	2363	59.3	1804	58.6	2263	58.5	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	2058	20.1	2370	22.6	2413	20.6	1962	20.1	2470	20.4	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	1987	0.1	2279	0.0	2326	0.0	1917	0.0	2391	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	2051	30.6	2364	33.2	2398	30.3	1958	30.3	2460	28.0	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	2060	15.1	2264	17.4	2411	15.7	1954	16.7	2469	17.5	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	2047	8.2	2254	11.4	2397	10.4	1950	8.8	2452	10.0	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	693	41.1	848	40.2	911	36.7	728	40.4	1110	38.6	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	681	0.1	827	0.2	890	0.9	721	0.7	1092	0.9	11.7 (0.0–73.7)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	685	41.5	842	38.0	909	36.7	728	40.8	1096	37.8	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	693	37.8	845	32.7	912	30.8	727	34.9	1107	31.8	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	685	33.1	837	28.9	908	26.4	723	31.8	1093	29.2	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	721	24.3	791	24.3	860	19.7	774	20.3	1195	19.5	18.7 (0.0–47.2)	↓*
	Ceftazidime resistance	729	23.9	804	22.5	882	18.4	772	20.6	1221	19.8	15.8 (2.3–46.0)	↓
	Carbapenem (imipenem/meropenem) resistance	733	36.6	807	37.3	883	33.2	779	33.8	1226	34.3	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	732	23.4	805	26.0	879	20.3	777	22.0	1221	22.2	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	734	14.6	784	17.9	883	16.9	761	11.4	1207	9.9	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	712	18.5	763	20.6	854	17.7	751	15.6	1170	16.2	12.6 (0.0–42.1)	↓*
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	358	52.0	357	55.2	418	51.0	534	73.0	1445	83.0	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	352	67.0	356	66.0	412	63.3	530	77.0	1441	85.6	43.0 (1.5–99.8)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	358	56.1	343	48.7	419	50.6	532	72.4	1434	81.8	39.6 (2.1–98.8)	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	352	48.6	341	41.3	410	45.6	529	69.4	1429	80.1	36.8 (0.0–98.5)	↑*
S. aureus	MRSA[f]	1566	23.6	1721	23.1	1884	19.4	1513	21.0	2359	19.3	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	204	6.9	207	10.1	222	6.3	124	8.9	185	12.4	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	187	11.8	190	14.7	215	12.1	115	17.4	175	14.9	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	187	6.4	190	7.9	215	5.1	115	8.7	174	6.3	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	769	41.5	750	38.0	816	33.7	962	42.6	1561	40.4	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	315	28.3	301	39.5	304	35.9	471	34.8	710	40.7	17.2 (0.0–66.4)	↑*

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Iceland

Participating institutions

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

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Iceland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	100	100	100	100
Geographical representativeness	ND	High	High	High	High
Hospital representativeness	ND	High	High	High	High
Isolate representativeness	ND	High	High	High	High
Blood culture sets/1 000 patient days	ND	50.6	61.6	61.3	64.4

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Iceland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	50	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	50	100	NA	100

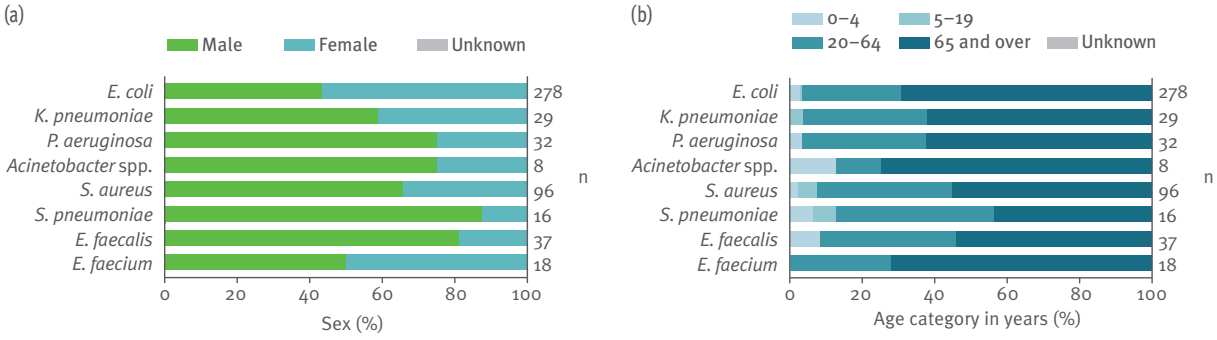
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Iceland, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	2	213	1	2	198	2	2	257	2	2	245	2	2	278	1
K. pneumoniae	2	17	NA	2	16	NA	2	23	0[c]	2	32	3	2	29	4[c]
P. aeruginosa	1	17	NA	2	12	NA	2	22	14[c]	2	25	19[c]	2	32	7
Acinetobacter spp.	1	6	NA	1	2	NA	1	3	NA	1	3	NA	1	8	NA
S. aureus	2	69	10	2	82	9	2	121	4	2	116	6	2	96	4
S. pneumoniae	2	27	4[c]	2	31	3	2	44	0	2	20	0[c]	2	16	NA
E. faecalis	2	33	9	2	30	7	2	35	9	2	30	7	2	37	6
E. faecium	1	17	NA	2	16	NA	2	13	NA	2	19	NA	2	18	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Iceland, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Iceland, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	213	41.3	198	49.0	257	52.5	245	55.1	277	46.6	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	213	6.1	198	8.1	257	7.0	245	11.0	278	10.4	13.8 (5.5–37.3)	↑*
	Carbapenem (imipenem/meropenem) resistance	8	NA	13	NA	2	NA	245	0.0	276	0.0	0.2 (0.0–1.1)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	199	11.6	192	17.2	252	13.1	245	11.8	277	14.4	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	213	5.6	197	6.1	256	4.7	245	7.8	278	9.4	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	199	1.5	191	2.1	251	0.4	245	3.3	277	2.9	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	17	NA	16	NA	23	4.3[h]	32	0.0	29	3.4[h]	34.3 (3.4–81.4)	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	1	NA	ND	ND	32	0.0	29	0.0[h]	11.7 (0.0–73.7)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	16	NA	16	NA	23	4.3[h]	32	0.0	29	0.0[h]	33.6 (0.0–80.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	17	NA	16	NA	23	8.7[h]	32	0.0	29	0.0[h]	23.7 (0.0–69.1)	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	16	NA	16	NA	23	0.0[h]	32	0.0	29	0.0[h]	21.2 (0.0–67.4)	NA
P. aeruginosa	Piperacillin-tazobactam resistance	ND	ND	ND	ND	2	NA	ND	ND	31	19.4	18.7 (0.0–47.2)	NA
	Ceftazidime resistance	17	NA	12	NA	22	13.6[h]	25	8.0[h]	32	9.4	15.8 (2.3–46.0)	NA
	Carbapenem (imipenem/meropenem) resistance	17	NA	12	NA	22	0.0[h]	25	12.0[h]	32	9.4	18.1 (3.5–45.9)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	17	NA	12	NA	22	4.5[h]	25	4.0[h]	32	6.3	18.7 (3.3–48.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	17	NA	12	NA	22	4.5[h]	25	0.0[h]	32	0.0	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	ND	ND	ND	ND	2	NA	ND	ND	31	3.2	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	6	NA	2	NA	3	NA	3	NA	8	NA	39.9 (0.0–99.5)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	6	NA	2	NA	3	NA	3	NA	8	NA	43.0 (1.5–99.8)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	6	NA	2	NA	3	NA	3	NA	8	NA	39.6 (2.1–98.8)	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	6	NA	2	NA	3	NA	3	NA	8	NA	36.8 (0.0–98.5)	NA
S. aureus	MRSA[f]	69	1.4	82	0.0	121	5.8	116	5.2	95	1.1	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	27	18.5[h]	31	9.7	44	15.9	20	30.0[h]	16	NA	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	27	18.5[h]	31	12.9	44	15.9	20	30.0[h]	16	NA	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	27	14.8[h]	31	9.7	44	11.4	20	30.0[h]	16	NA	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	33	18.2	30	16.7	35	11.4	30	6.7	37	8.1	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	17	NA	16	NA	13	NA	19	NA	18	NA	17.2 (0.0–66.4)	NA

ND: no data available.
NA: not applicable.
[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.
[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Ireland

Participating institutions

Health Protection Surveillance Centre

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Ireland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	96	96	96
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	58.0	57.3	58.9	56.5	56.5

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Ireland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	94	97	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	85	87	84	NA	ND

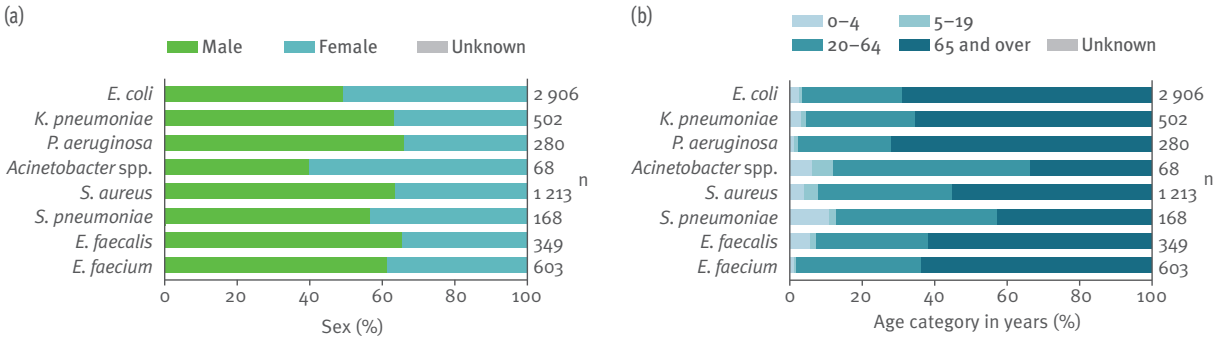
ND: no data available.
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Ireland, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	39	3125	NA	38	3239	NA	34	3233	NA	33	2851	NA	32	2906	NA
K. pneumoniae	35	479	NA	34	483	NA	30	527	NA	33	487	NA	31	502	NA
P. aeruginosa	33	288	NA	29	273	NA	27	276	NA	26	264	NA	26	280	NA
Acinetobacter spp.	23	66	NA	17	62	NA	21	66	NA	17	54	NA	17	68	NA
S. aureus	37	1144	NA	37	1188	NA	32	1146	NA	31	1024	NA	32	1213	NA
S. pneumoniae	31	412	NA	32	455	NA	27	348	NA	27	177	NA	24	168	NA
E. faecalis	33	340	NA	36	332	NA	30	301	NA	31	312	NA	31	349	NA
E. faecium	33	442	NA	30	419	NA	27	443	NA	26	472	NA	25	603	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Ireland, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Ireland, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	2991	69.8	3237	67.6	3201	67.5	2841	65.0	2898	63.0	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	3121	12.0	3237	12.9	3231	12.1	2850	11.8	2903	10.0	13.8 (5.5–37.3)	↓*
	Carbapenem (imipenem/meropenem) resistance	3116	0.0	3237	0.0	3229	0.0	2820	0.1	2891	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	3119	23.6	3238	23.9	3223	20.4	2844	18.9	2898	16.0	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	3123	11.9	3238	11.7	3232	11.8	2849	10.6	2904	9.6	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	3116	5.7	3235	6.1	3222	5.6	2841	4.7	2895	4.0	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	478	14.6	483	14.5	527	17.6	487	18.7	502	15.5	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	478	0.2	482	0.6	527	0.9	477	0.4	497	0.6	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	478	14.9	483	18.0	526	17.3	486	17.1	500	16.2	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	479	11.9	483	13.0	526	11.0	485	11.5	502	10.6	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	477	5.9	483	8.1	525	5.3	484	7.9	500	7.6	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	286	14.0	270	8.1	276	10.9	241	12.9	262	15.3	18.7 (0.0–47.2)	–
	Ceftazidime resistance	272	9.6	261	8.4	272	9.2	240	10.4	277	11.2	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	288	9.0	273	6.6	275	6.5	261	7.3	280	8.2	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	287	13.9	272	8.8	276	9.4	262	13.7	277	8.7	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	288	8.7	273	5.5	276	6.5	161	1.9	244	3.3	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	269	8.2	258	3.1	272	5.1	138	1.4	225	6.2	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	63	6.3	60	1.7	63	1.6	52	0.0	66	1.5	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	66	7.6	61	0.0	64	7.8	41	7.3	60	3.3	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	62	3.2	56	3.6	57	1.8	48	2.1	64	3.1	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	59	1.7	55	0.0	53	0.0	35	0.0	56	0.0	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	1140	16.3	1188	12.4	1146	12.6	1024	11.6	1213	10.6	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	412	15.8	455	20.7	348	14.4	177	15.8	168	19.6	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	396	12.9	419	13.6	340	12.6	170	12.9	159	12.6	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	396	9.3	419	10.0	340	8.2	170	10.0	159	7.5	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	302	30.8	292	23.6	243	23.0	175	16.0	260	17.3	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	442	38.2	418	40.2	443	38.4	471	35.7	602	27.6	17.2 (0.0–66.4)	↓*

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Italy

Participating institutions

National Institute of Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Italy, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	21	36	41	47	61
Geographical representativeness	Medium	High	High	High	High
Hospital representativeness	ND	High	High	High	High
Isolate representativeness	ND	High	High	High	High
Blood culture sets/1 000 patient days	ND	55.4	ND	57.0	66.6

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Italy, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	97	95	95	NA	98

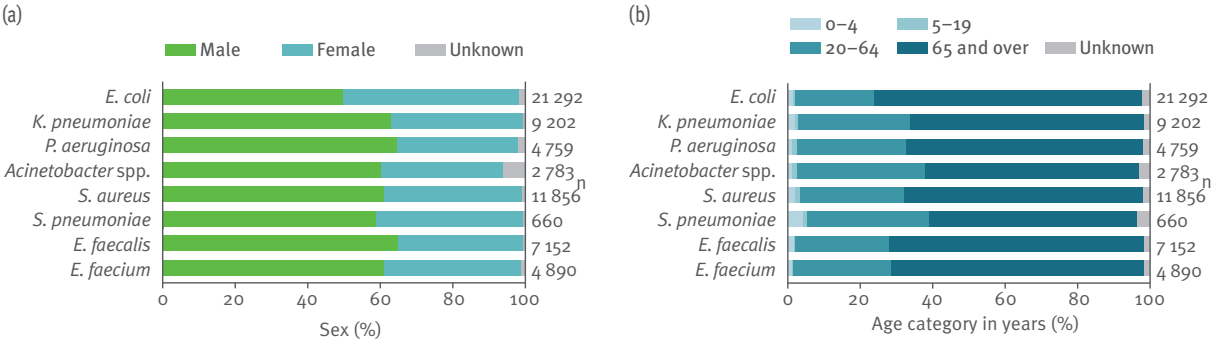
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Italy, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	54	7478	7	97	16539	7	128	18866	6	151	19086	6	135	21292	7
K. pneumoniae	55	2720	27	98	5913	23	123	7782	22	147	8597	24	134	9202	23
P. aeruginosa	54	1455	25	95	3050	23	124	3895	23	145	4678	27	134	4759	25
Acinetobacter spp.	48	878	42	92	1392	42	100	1651	38	123	2577	48	113	2783	52
S. aureus	55	4213	16	97	8581	12	125	9943	11	149	11164	14	132	11856	13
S. pneumoniae	52	673	9	80	1160	9	100	1351	10	109	685	10	101	660	13
E. faecalis	55	2004	26	94	4153	19	122	4705	18	149	6354	28	130	7152	25
E. faecium	54	1085	22	92	2304	19	118	2878	19	138	4243	26	131	4890	24

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Italy, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Italy, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	4078	67.1	7533	64.5	4457	68.1	4214	64.5	5518	58.9	53.1 (31.7–70.2)	↓
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	7077	29.5	16253	28.7	18409	30.9	18750	26.4	21153	23.8	13.8 (5.5–37.3)	↓*
	Carbapenem (imipenem/meropenem) resistance	7280	0.3	15452	0.4	17086	0.4	18001	0.5	19905	0.4	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	6945	44.9	16043	41.7	18417	40.6	18840	37.6	20989	32.5	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	7134	18.4	15901	16.0	18382	15.9	17994	14.9	20614	13.2	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	6454	13.7	15622	11.4	17961	11.6	17593	9.8	20392	8.3	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	2546	54.6	5832	53.6	7699	57.6	8400	54.3	9094	53.3	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	2633	29.5	5660	26.8	7325	28.5	8293	29.5	8760	26.7	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	2562	55.7	5752	52.7	7692	54.7	8486	52.4	9028	50.0	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	2571	34.5	5693	27.0	7682	32.6	8084	31.6	8821	30.1	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	2352	31.6	5587	24.8	7560	30.3	7842	29.5	8712	27.5	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	1309	23.2	2938	23.9	3768	24.1	4537	24.2	4530	23.4	18.7 (0.0–47.2)	–
	Ceftazidime resistance	1332	20.0	2974	19.9	3798	19.0	4473	19.3	4560	19.1	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	1433	19.6	3014	15.8	3794	13.7	4615	15.9	4708	16.4	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1390	25.1	2994	22.9	3875	21.7	4599	19.6	4665	18.6	18.7 (3.3–48.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	1428	18.0	2983	12.8	3859	11.4	ND	ND	ND	ND	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	1182	15.9	2849	14.5	3581	13.0	ND	ND	ND	ND	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	868	78.7	1383	79.2	1588	79.3	2552	80.8	2734	86.9	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	804	79.2	1368	81.1	1636	82.5	2522	83.4	2729	88.1	43.0 (1.5–99.8)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	836	76.1	1369	77.0	1637	78.8	2496	80.2	2697	85.1	39.6 (2.1–98.8)	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	763	72.6	1351	75.7	1569	76.6	2451	78.7	2649	84.7	36.8 (0.0–98.5)	↑*
S. aureus	MRSA[f]	3591	33.9	8263	34.0	9681	34.3	10923	33.5	11344	30.0	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	522	10.5	928	9.2	1017	11.9	516	13.4	481	10.0	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	599	22.7	1095	20.3	1298	22.3	639	24.1	630	24.0	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	474	5.3	879	4.7	989	6.7	491	7.7	463	6.5	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	1630	45.9	2927	39.9	2395	34.9	3028	37.4	3018	36.3	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	1049	14.6	2273	18.9	2839	21.3	4166	23.6	4736	28.2	17.2 (0.0–66.4)	↑*

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Kazakhstan

Participating institutions

Scientific and Practical Center for Sanitary and Epidemiological Expertise and Monitoring, National Center for Public Health, Ministry of Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Kazakhstan, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	ND	ND	ND
Geographical representativeness	ND	ND	ND	ND	Low
Hospital representativeness	ND	ND	ND	ND	Low
Isolate representativeness	ND	ND	ND	ND	Low
Blood culture sets/1 000 patient days[a]	ND	ND	ND	ND	12 (3–21)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Kazakhstan, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	ND	ND	ND	ND	50
Percentage of laboratories participating in CAESAR EQA	ND	ND	ND	ND	43

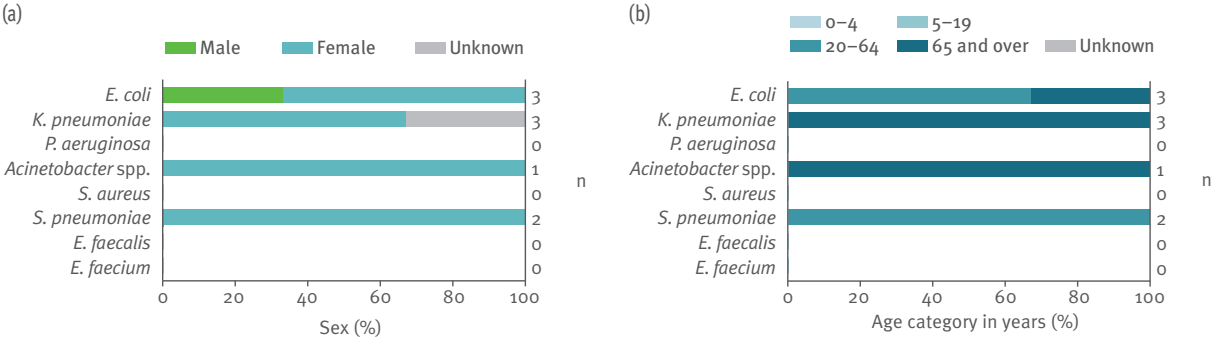
ND: no data available.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Kazakhstan, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	3	NA
K. pneumoniae	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	3	NA
P. aeruginosa	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acinetobacter spp.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	1	NA
S. aureus	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S. pneumoniae	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	2	NA
E. faecalis	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E. faecium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Labs: laboratories.
NA: not applicable.
ND: no data available.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Kazakhstan, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Kazakhstan, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	ND	ND	ND	ND	ND	ND	3	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	3	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	3	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	3	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	ND	ND	ND	ND	3	NA	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	3	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
P. aeruginosa	Piperacillin-tazobactam resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Ceftazidime resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
S. aureus	MRSA[d]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
S. pneumoniae	Penicillin non-wild-type[e]	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
E. faecalis	High-level gentamicin resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
E. faecium	Vancomycin resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

Kosovo[1]

Participating institutions

National Institute of Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Kosovo[1], 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	90	90	90	90	59
Geographical representativeness	Medium	Medium	High	High	Medium
Hospital representativeness	Low	Low	High	High	Low
Isolate representativeness	Low	Low	Low	Low	Low
Blood culture sets/1 000 patient days[a]	6	5	5 (5–6)	6 (6–6)	7

Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Kosovo[1], 2017–2021

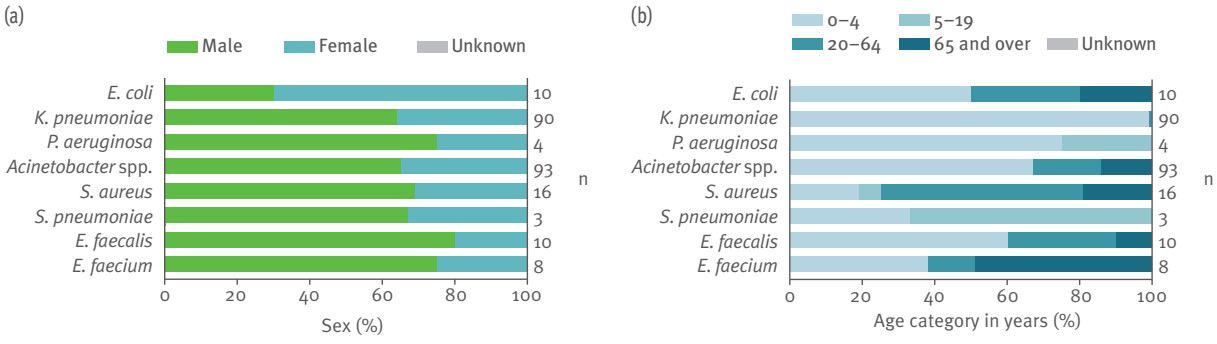
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100	100	100
Percentage of laboratories participating in CAESAR EQA	100	100	100	50	100

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Kosovo[1], 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	1	19	NA	1	12	NA	2	17	NA	2	10	NA	1	10	NA
K. pneumoniae	1	38	3	1	66	94	2	55	84	2	77	91	1	90	98
P. aeruginosa	1	19	NA	1	13	NA	2	14	NA	1	2	NA	1	4	NA
Acinetobacter spp.	1	70	10	1	70	93	1	45	98	2	59	88	1	93	88
S. aureus	1	19	NA	1	26	54[c]	2	29	31[c]	2	14	NA	1	16	NA
S. pneumoniae	1	4	NA	1	4	NA	1	3	NA	ND	ND	ND	1	3	NA
E. faecalis	1	11	NA	1	11	NA	2	16	NA	2	7	NA	1	10	NA
E. faecium	1	8	NA	1	5	NA	2	7	NA	2	4	NA	1	8	NA

Labs: laboratories.
NA: not applicable.
ND: no data available.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Kosovo[1], 2021



1 This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the International Court of Justice Opinion on the Kosovo Declaration of Independence.

Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Kosovo[1], 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	19	NA	12	NA	17	NA	10	NA	10	NA	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	19	NA	12	NA	17	NA	10	NA	10	NA	NA
	Carbapenem (imipenem/meropenem) resistance	19	NA	12	NA	17	NA	10	NA	10	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	19	NA	12	NA	17	NA	10	NA	10	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	19	NA	12	NA	17	NA	10	NA	10	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	19	NA	12	NA	17	NA	10	NA	10	NA	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	38	97.4	66	97.0	55	85.5	77	92.2	90	96.7	NA
	Carbapenem (imipenem/meropenem) resistance	38	0.0	66	1.5	55	0.0	77	0.0	90	1.1	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	38	7.9	66	6.1	55	16.4	77	0.0	90	2.2	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	38	97.4	66	95.5	55	81.8	77	90.9	90	95.6	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	38	7.9	66	6.1	55	16.4	77	0.0	90	2.2	NA
P. aeruginosa	Piperacillin-tazobactam resistance	19	NA	13	NA	14	NA	2	NA	4	NA	NA
	Ceftazidime resistance	19	NA	13	NA	14	NA	2	NA	4	NA	NA
	Carbapenem (imipenem/meropenem) resistance	19	NA	13	NA	14	NA	2	NA	4	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	19	NA	13	NA	14	NA	2	NA	4	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	19	NA	13	NA	14	NA	2	NA	4	NA	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	19	NA	13	NA	14	NA	2	NA	4	NA	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	70	88.6	70	88.6	45	93.3	59	84.7	93	84.9	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	70	88.6	70	87.1	45	91.1	59	84.7	93	84.9	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	70	92.9	70	90.0	45	91.1	59	72.9	93	94.6	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	70	88.6	70	87.1	45	91.1	59	71.2	93	81.7	NA
S. aureus	MRSA[d]	19	NA	26	57.7[f]	29	34.5[f]	14	NA	16	NA	NA
S. pneumoniae	Penicillin non-wild-type[e]	4	NA	4	NA	3	NA	ND	ND	3	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	4	NA	4	NA	3	NA	ND	ND	3	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	4	NA	4	NA	3	NA	ND	ND	3	NA	NA
E. faecalis	High-level gentamicin resistance	11	NA	11	NA	16	NA	7	NA	10	NA	NA
E. faecium	Vancomycin resistance	8	NA	5	NA	7	NA	4	NA	8	NA	NA

NA: not applicable.
ND: no data available.
[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[c] The aminoglycoside group includes only tobramycin from 2020 onwards.
[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.
[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

[1] This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the International Court of Justice Opinion on the Kosovo Declaration of Independence.

Latvia

Participating institutions

Disease Prevention and Control Center of Latvia

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Latvia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	90	90	90	90	90
Geographical representativeness	High	High	High	High	High
Hospital representativeness	Medium	Medium	Medium	Medium	Medium
Isolate representativeness	Medium	Medium	Medium	Medium	Medium
Blood culture sets/1 000 patient days	6.1	8.0	9.5	13.8	17.0

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Latvia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	21	53	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	88	100	100	NA	ND

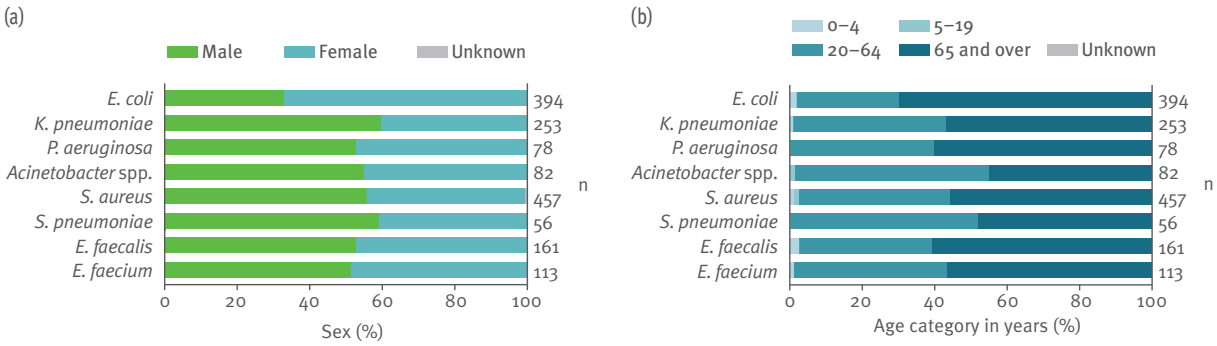
ND: no data available.
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Latvia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	12	205	23	11	348	27	10	442	20	10	379	21	11	394	20
K. pneumoniae	7	116	41	13	204	36	9	198	32	9	189	29	10	253	38
P. aeruginosa	4	14	NA	4	39	31	6	49	44	9	43	31	9	78	51
Acinetobacter spp.	7	34	62	7	51	65	8	46	61	7	52	54	8	82	67
S. aureus	11	229	22	14	376	20	11	422	20	10	355	21	11	457	15
S. pneumoniae	9	53	38	7	69	38	6	79	33	5	42	38	7	56	22
E. faecalis	8	74	38	10	89	38	10	100	25	9	98	28	10	161	39
E. faecium	5	39	54	7	49	41	8	58	43	9	62	48	8	113	60

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Latvia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Latvia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	202	60.4	347	56.2	438	57.8	374	54.3	344	49.4	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	205	22.0	348	20.4	442	19.7	378	24.1	393	18.3	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	203	0.0	346	0.0	439	0.0	378	0.0	393	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	201	30.3	344	24.1	442	24.9	378	27.5	392	20.7	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	201	13.4	348	8.9	440	11.6	377	11.4	394	10.9	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	197	11.2	344	7.0	440	9.3	376	10.6	391	8.4	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	116	33.6	204	37.7	198	36.9	188	48.4	253	36.0	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	116	1.7	204	0.5	198	0.0	189	1.1	253	1.6	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	116	32.8	200	38.5	198	36.9	188	41.5	252	31.0	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	115	29.6	203	31.0	198	28.3	186	21.0	252	22.2	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	115	24.3	199	27.6	198	25.3	185	19.5	251	20.3	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	14	NA	39	35.9	45	35.6	14	NA	76	27.6	18.7 (0.0–47.2)	NA
	Ceftazidime resistance	14	NA	39	33.3	49	32.7	42	23.8	77	26.0	15.8 (2.3–46.0)	NA
	Carbapenem (imipenem/meropenem) resistance	14	NA	39	28.2	49	32.7	43	25.6	78	29.5	18.1 (3.5–45.9)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	14	NA	39	23.1	49	28.6	39	30.8	78	32.1	18.7 (3.3–48.0)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	14	NA	39	28.2	49	22.4	7	NA	23	17.4[h]	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	14	NA	39	30.8	45	20.0	5	NA	23	13.0[h]	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	34	79.4	51	78.4	46	84.8	52	82.7	82	79.3	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	33	81.8	47	80.9	24	83.3[h]	50	86.0	60	86.7	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	33	78.8	48	60.4	44	68.2	52	63.5	82	68.3	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	32	75.0	44	56.8	22	50.0[h]	50	64.0	60	70.0	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	210	5.7	315	5.7	421	7.8	353	9.3	457	5.3	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	51	17.6	69	10.1	79	10.1	41	17.1	56	3.6	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	28	3.6[h]	66	9.1	76	5.3	27	11.1[h]	34	0.0	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	28	3.6[h]	66	6.1	76	3.9	27	3.7[h]	34	0.0	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	72	45.8	86	32.6	93	44.1	89	38.2	153	46.4	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	39	25.6	48	35.4	58	39.7	62	29.0	113	30.1	17.2 (0.0–66.4)	–

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Lithuania

Participating institutions

National Public Health Surveillance Laboratory
Institute of Hygiene

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Lithuania, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	100	100	100
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	6.3	5.3	6.1	8.1	9.8

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Lithuania, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	94	89	NA	100

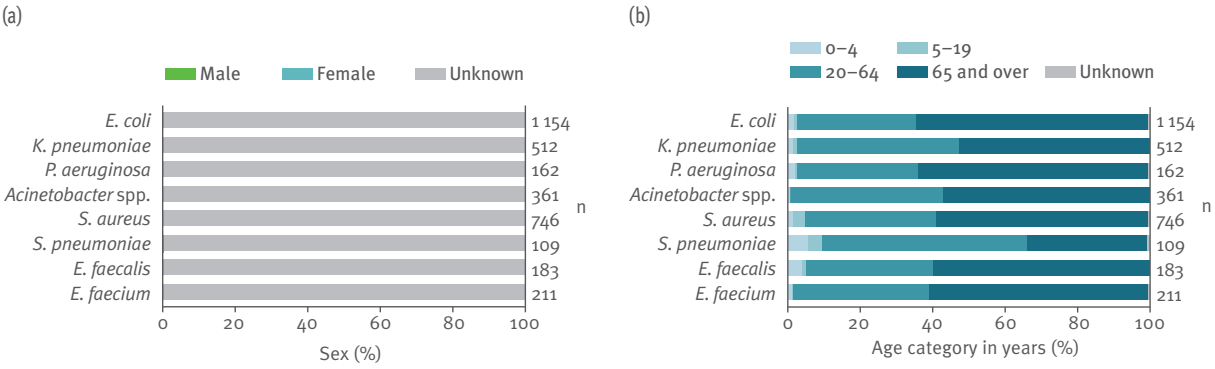
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Lithuania, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	16	852	19	17	1109	17	18	1132	20	17	1142	18	17	1154	16
K. pneumoniae	15	326	30	17	371	24	17	440	28	16	413	25	14	512	29
P. aeruginosa	13	89	36	13	101	32	17	104	32	15	121	26	12	162	35
Acinetobacter spp.	12	87	56	13	88	58	13	108	57	12	157	71	13	361	78
S. aureus	16	515	20	18	693	24	18	656	21	17	704	22	16	746	21
S. pneumoniae	14	109	27	13	93	29	16	120	38	14	96	22	15	109	25
E. faecalis	13	111	26	14	138	25	15	143	30	14	140	28	14	183	41
E. faecium	13	80	33	14	99	34	14	128	38	15	145	43	13	211	44

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Lithuania, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Lithuania, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	845	57.8	1106	59.0	1129	59.1	1138	56.9	1147	57.1	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	852	16.8	1109	15.3	1132	13.9	1142	15.9	1153	13.6	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	849	0.0	1100	0.0	1122	0.2	1142	0.0	1149	0.3	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	849	25.2	1104	19.7	1129	18.0	1136	18.8	1139	17.6	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	848	8.3	1103	7.9	1129	7.6	1141	10.3	1141	8.3	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	845	4.4	1098	4.6	1126	4.5	1135	6.4	1126	5.0	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	326	63.2	371	55.8	440	55.0	413	42.6	512	43.0	34.3 (3.4–81.4)	↓*
	Carbapenem (imipenem/meropenem) resistance	325	0.6	371	0.3	438	3.4	413	2.9	511	1.0	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	326	64.7	370	56.8	438	52.1	413	45.3	510	38.2	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	322	53.7	369	48.5	435	39.8	410	33.9	511	29.0	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	322	48.1	368	45.1	433	35.3	410	28.5	509	25.0	21.2 (0.0–67.4)	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	89	18.0	101	17.8	102	23.5	121	23.1	162	14.2	18.7 (0.0–47.2)	–
	Ceftazidime resistance	88	14.8	101	11.9	103	15.5	119	16.8	160	13.1	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	89	24.7	101	21.8	104	16.3	121	25.6	161	25.5	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	89	21.3	101	12.9	104	17.3	120	18.3	158	16.5	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	89	13.5	101	9.9	103	12.6	ND	ND	ND	ND	8.9 (0.0–41.7)	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	88	17.0	101	11.9	101	12.9	ND	ND	ND	ND	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	87	88.5	88	89.8	108	85.2	157	91.1	360	96.1	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	86	91.9	88	90.9	108	91.7	154	92.9	361	96.7	43.0 (1.5–99.8)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	86	81.4	87	85.1	107	83.2	153	86.3	351	93.4	39.6 (2.1–98.8)	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	85	77.6	87	85.1	107	78.5	150	86.7	350	92.9	36.8 (0.0–98.5)	↑*
S. aureus	MRSA[f]	514	8.8	691	8.4	656	9.3	704	9.8	746	9.0	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	109	15.6	93	19.4	120	10.8	96	13.5	109	8.3	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	107	15.9	92	20.7	119	10.1	96	14.6	109	18.3	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	107	11.2	92	13.0	119	7.6	96	9.4	109	4.6	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	60	36.7	65	27.7	78	41.0	68	13.2	94	18.1	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	80	36.3	99	31.3	128	39.8	145	56.6	211	66.4	17.2 (0.0–66.4)	↑*

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Luxembourg

Participating institutions

National Health Laboratory
Microbiology Laboratory, Centre Hospitalier de Luxembourg

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Luxembourg, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	ND	99	100
Geographical representativeness	ND	High	ND	High	High
Hospital representativeness	ND	High	ND	High	High
Isolate representativeness	ND	High	ND	High	High
Blood culture sets/1 000 patient days	ND	28.2	ND	38.9	42.1

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Luxembourg, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	100	NA	100

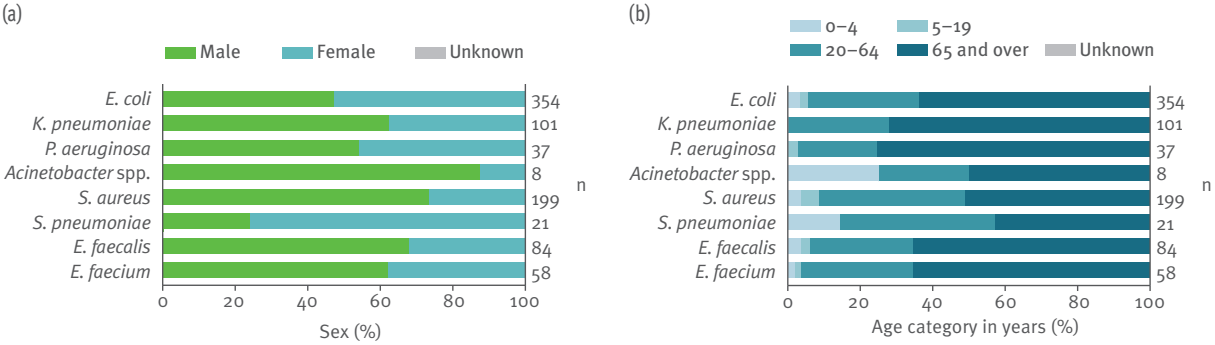
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Luxembourg, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	4	433	8	4	424	11	4	492	8	4	428	8	4	354	10
K. pneumoniae	4	99	21	4	85	18	4	103	18	4	87	23	4	101	20
P. aeruginosa	4	56	21	4	59	7	4	56	18	3	51	14	3	37	27
Acinetobacter spp.	2	8	NA	2	11	NA	3	10	NA	2	7	NA	2	8	NA
S. aureus	4	200	17	4	181	13	4	209	15	4	195	18	4	199	20
S. pneumoniae	4	49	12	4	45	21	4	38	11	3	24	13[c]	4	21	5[c]
E. faecalis	4	87	27	4	51	20	4	82	24	4	95	37	4	84	37
E. faecium	4	34	32	4	29	18[c]	4	37	32	3	42	20	4	58	38

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Luxembourg, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Luxembourg, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	433	55.9	420	55.2	492	57.5	427	52.5	352	53.4	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	433	9.7	424	12.5	492	12.6	428	11.4	354	11.3	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	433	0.0	424	0.0	492	0.6	428	0.0	354	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	433	22.9	418	21.8	492	20.5	428	21.7	354	20.9	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	433	10.4	423	7.3	492	10.2	428	8.9	354	8.8	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	433	3.5	417	3.8	492	3.9	428	4.0	354	4.2	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	99	27.3	85	29.4	103	25.2	87	26.4	101	25.7	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	99	0.0	85	0.0	103	1.0	87	1.1	101	1.0	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	99	28.3	85	24.7	103	27.2	87	31.0	101	23.8	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	99	18.2	85	20.0	103	17.5	87	20.7	101	14.9	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	99	17.2	85	15.3	103	13.6	87	20.7	101	12.9	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	54	11.1	56	12.5	44	2.3	51	5.9	35	0.0	18.7 (0.0–47.2)	⇣*
	Ceftazidime resistance	56	12.5	59	8.5	56	3.6	50	4.0	37	8.1	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	56	10.7	54	11.1	31	9.7	47	8.5	37	8.1	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	56	12.5	59	22.0	56	8.9	50	22.0	37	24.3	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	56	5.4	53	3.8	56	1.8	40	2.5	37	2.7	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	54	3.7	51	2.0	19	NA	40	5.0	35	0.0	12.6 (0.0–42.1)	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	8	NA	6	NA	8	NA	7	NA	8	NA	39.9 (0.0–99.5)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	8	NA	11	NA	10	NA	7	NA	8	NA	43.0 (1.5–99.8)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	8	NA	11	NA	10	NA	7	NA	8	NA	39.6 (2.1–98.8)	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	8	NA	6	NA	8	NA	7	NA	8	NA	36.8 (0.0–98.5)	NA
S. aureus	MRSA[f]	200	9.5	181	7.7	209	6.2	195	3.1	199	5.5	15.8 (0.9–42.9)	⇣*
S. pneumoniae	Penicillin non-wild-type[g]	45	6.7	45	11.1	38	21.1	24	16.7[h]	21	14.3[h]	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	49	8.2	45	11.1	38	7.9	24	12.5[h]	21	28.6[h]	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	45	4.4	45	4.4	38	2.6	24	0.0[h]	21	9.5[h]	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	82	22.0	45	6.7	82	4.9	95	10.5	84	11.9	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	34	0.0	28	0.0[h]	37	2.7	42	11.9	58	0.0	17.2 (0.0–66.4)	–

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ⇡ and ⇣ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Malta

Participating institutions

Malta Mater Dei Hospital, Msida

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Malta, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	95	95	95	95	95
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	26.3	29.2	28.5	35.2	37.7

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Malta, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	100	NA	100

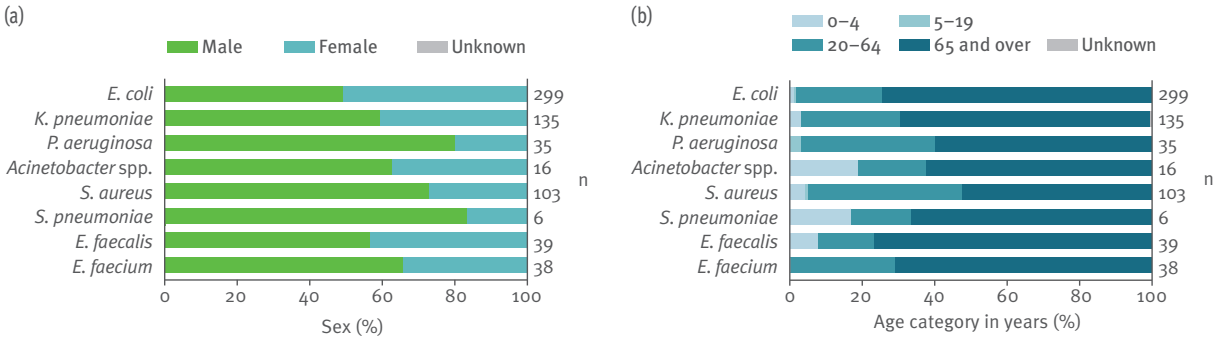
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Malta, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	1	314	1	1	332	2	1	332	1	1	277	2	1	299	4
K. pneumoniae	1	117	10	1	137	13	1	129	10	1	132	6	1	135	14
P. aeruginosa	1	37	19	1	29	14[c]	1	39	23	1	49	13	1	35	29
Acinetobacter spp.	1	9	NA	1	9	NA	1	15	NA	1	7	NA	1	16	NA
S. aureus	1	97	1	1	90	10	1	75	7	1	92	6	1	103	8
S. pneumoniae	1	19	NA	1	37	0	1	27	0[c]	1	16	NA	1	6	NA
E. faecalis	1	29	5[c]	1	32	6	1	30	3	1	28	20[c]	1	39	16
E. faecium	1	13	NA	1	15	NA	1	13	NA	1	23	24[c]	1	38	42

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Malta, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Malta, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	314	59.6	332	59.6	332	64.8	277	58.5	299	64.5	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	314	15.6	332	15.4	332	17.5	277	12.3	299	13.7	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	314	0.0	332	0.0	332	0.0	277	0.0	299	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	314	43.3	332	41.9	332	40.1	277	35.4	299	30.8	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	314	10.8	332	9.9	332	9.9	277	12.6	299	12.7	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	314	6.4	332	4.5	332	5.1	277	8.3	299	8.0	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	117	35.0	137	53.3	129	37.2	132	38.6	135	28.9	34.3 (3.4–81.4)	↓*
	Carbapenem (imipenem/meropenem) resistance	117	10.3	136	15.4	129	7.8	132	7.6	135	6.7	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	117	39.3	137	55.5	129	44.2	132	37.1	135	34.8	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	117	31.6	137	46.7	129	26.4	132	23.5	135	20.0	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	117	28.2	137	43.8	129	22.5	132	18.9	135	16.3	21.2 (0.0–67.4)	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	37	18.9	29	17.2[h]	39	15.4	49	18.4	35	28.6	18.7 (0.0–47.2)	–
	Ceftazidime resistance	37	13.5	29	13.8[h]	39	15.4	49	12.2	35	14.3	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	37	10.8	29	3.4[h]	39	7.7	49	8.2	35	11.4	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	37	10.8	29	0.0[h]	39	12.8	49	16.3	35	8.6	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	37	10.8	29	0.0[h]	39	5.1	49	2.0	35	2.9	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	37	8.1	29	3.4[h]	39	7.7	49	10.2	35	8.6	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	9	NA	9	NA	15	NA	7	NA	16	NA	39.9 (0.0–99.5)	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	9	NA	9	NA	15	NA	7	NA	16	NA	43.0 (1.5–99.8)	NA
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	9	NA	8	NA	14	NA	7	NA	16	NA	39.6 (2.1–98.8)	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	9	NA	8	NA	14	NA	7	NA	16	NA	36.8 (0.0–98.5)	NA
S. aureus	MRSA[f]	95	42.1	88	36.4	75	24.0	92	19.6	103	20.4	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	19	NA	37	24.3	27	33.3[h]	16	NA	6	NA	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	19	NA	37	24.3	25	28.0[h]	16	NA	6	NA	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	19	NA	37	13.5	25	20.0[h]	16	NA	6	NA	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	29	34.5[h]	31	22.6	30	26.7	28	25.0[h]	38	15.8	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	13	NA	15	NA	13	NA	23	21.7[h]	38	55.3	17.2 (0.0–66.4)	NA

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Moldova

Participating institutions

National Agency for Public Health, Ministry of Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Moldova, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	70	70	49
Geographical representativeness	ND	ND	High	High	High
Hospital representativeness	ND	ND	High	High	High
Isolate representativeness	ND	ND	Low	Low	Low
Blood culture sets/1 000 patient days[a]	ND	ND	1 (0–7)	4 (0–24)	4 (0–12)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Moldova, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	ND	ND	100	100	100
Percentage of laboratories participating in CAESAR EQA	ND	ND	100	29	63

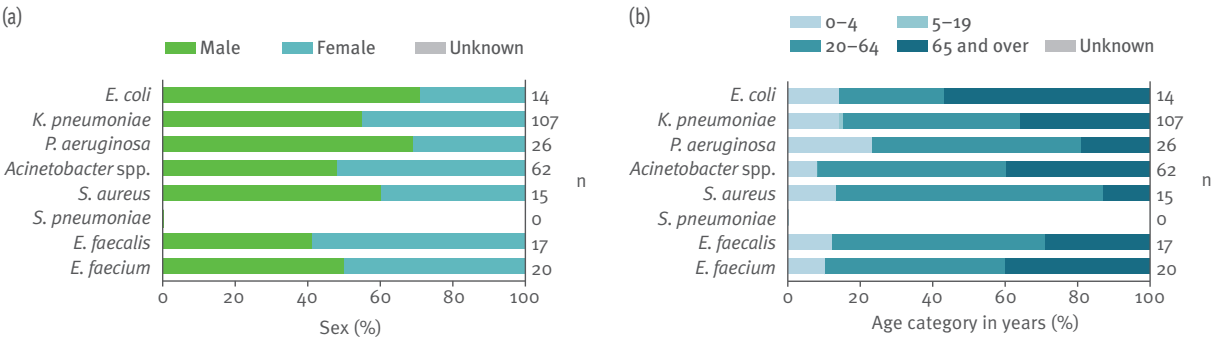
ND: no data available.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Moldova, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	ND	ND	ND	1	1	NA	2	22	77[c]	4	9	NA	4	14	NA
K. pneumoniae	ND	ND	ND	ND	ND	ND	3	39	82	7	78	64	5	107	45
P. aeruginosa	ND	ND	ND	ND	ND	ND	3	13	NA	2	10	NA	5	26	73[c]
Acinetobacter spp.	ND	ND	ND	ND	ND	ND	2	10	NA	3	58	59	4	62	47
S. aureus	ND	ND	ND	1	2	NA	5	23	39[c]	4	9	NA	6	15	NA
S. pneumoniae	ND	ND	ND	1	3	NA	2	2	NA	ND	ND	ND	ND	ND	ND
E. faecalis	ND	ND	ND	1	3	NA	2	6	NA	5	14	NA	4	17	NA
E. faecium	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	9	NA	6	20	58[c]

Labs: laboratories.
NA: not applicable.
ND: no data available.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Moldova, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Moldova, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	ND	ND	1	NA	11	NA	9	NA	14	NA	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	1	NA	22	59.1[f]	9	NA	14	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	1	NA	22	9.1[f]	9	NA	14	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	1	NA	22	50.0[f]	9	NA	14	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	22	18.2[f]	9	NA	14	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	22	9.1[f]	9	NA	14	NA	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	ND	ND	39	79.5	76	96.1	107	98.1	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	39	53.8	78	55.1	107	60.7	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	ND	ND	39	82.1	78	94.9	107	99.1	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	39	69.2	78	96.2	107	96.3	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	39	69.2	76	90.8	107	95.3	NA
P. aeruginosa	Piperacillin-tazobactam resistance	ND	ND	ND	ND	13	NA	10	NA	25	64.0[f]	NA
	Ceftazidime resistance	ND	ND	ND	ND	11	NA	10	NA	26	65.4[f]	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	13	NA	10	NA	26	73.1[f]	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	ND	ND	13	NA	10	NA	26	65.4[f]	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	ND	ND	ND	ND	13	NA	9	NA	24	75.0[f]	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	ND	ND	ND	ND	11	NA	9	NA	23	65.2[f]	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	10	NA	58	93.1	62	95.2	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	ND	ND	9	NA	58	98.3	62	100.0	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	10	NA	58	98.3	62	96.8	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	9	NA	58	93.1	62	91.9	NA
S. aureus	MRSA[d]	ND	ND	1	NA	23	21.7[f]	9	NA	15	NA	NA
S. pneumoniae	Penicillin non-wild-type[e]	ND	ND	3	NA	2	NA	ND	ND	ND	ND	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	ND	ND	3	NA	2	NA	ND	ND	ND	ND	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	ND	ND	3	NA	2	NA	ND	ND	ND	ND	NA
E. faecalis	High-level gentamicin resistance	ND	ND	3	NA	4	NA	13	NA	17	NA	NA
E. faecium	Vancomycin resistance	ND	ND	ND	ND	ND	ND	9	NA	20	35.0[f]	NA

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (› 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Montenegro

Participating institutions

Institute for Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Montenegro, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	100	100	100
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Low	Low	Low	Low	Low
Blood culture sets/1 000 patient days[a]	3 (0–15)	3 (1–16)	4 (0–18)	3 (0–25)	6 (1–17)

Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Montenegro, 2017–2021

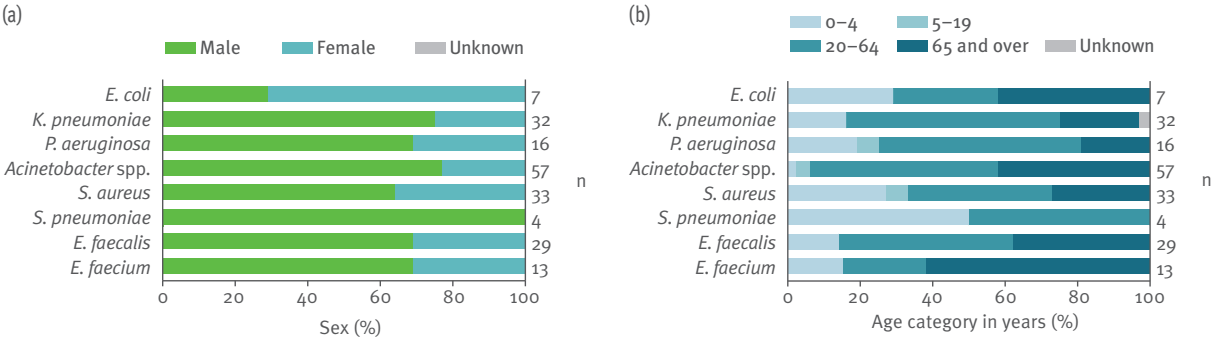
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	0	75	88	88	100
Percentage of laboratories participating in CAESAR EQA	100	100	100	100	100

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Montenegro, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	1	21	10[c]	4	29	21[c]	2	24	67[c]	4	20	26[c]	1	7	NA
K. pneumoniae	2	29	31[c]	2	22	32[c]	2	23	70[c]	3	29	55[c]	1	32	56
P. aeruginosa	2	14	NA	2	11	NA	1	16	NA	2	11	NA	1	16	NA
Acinetobacter spp.	1	10	NA	1	14	NA	1	32	59	2	37	59	2	57	35
S. aureus	4	36	17	4	41	15	3	43	47	4	31	29	3	33	24
S. pneumoniae	2	4	NA	2	7	NA	2	4	NA	2	3	NA	1	4	NA
E. faecalis	1	12	NA	2	5	NA	3	9	NA	3	15	NA	2	29	24[c]
E. faecium	1	6	NA	1	6	NA	2	8	NA	1	5	NA	1	13	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Montenegro, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Montenegro, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	18	NA	29	82.8[f]	23	73.9[f]	20	80.0[f]	7	NA	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	20	70.0[f]	29	62.1[f]	24	37.5[f]	20	40.0[f]	7	NA	NA
	Carbapenem (imipenem/meropenem) resistance	20	0.0[f]	29	0.0[f]	24	0.0[f]	20	0.0[f]	7	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	20	25.0[f]	29	55.2[f]	24	45.8[f]	20	40.0[f]	7	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	20	45.0[f]	29	51.7[f]	24	33.3[f]	20	30.0[f]	7	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	19	NA	29	37.9[f]	24	29.2[f]	20	15.0[f]	7	NA	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	29	96.6[f]	22	95.5[f]	23	87.0[f]	29	86.2[f]	32	87.5	NA
	Carbapenem (imipenem/meropenem) resistance	29	13.8[f]	22	4.5[f]	23	17.4[f]	29	13.8[f]	32	37.5	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	29	58.6[f]	22	63.6[f]	23	47.8[f]	29	62.1[f]	32	75.0	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	29	96.6[f]	22	90.9[f]	23	78.3[f]	29	86.2[f]	32	87.5	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	29	58.6[f]	22	59.1[f]	23	34.8[f]	29	62.1[f]	32	75.0	NA
P. aeruginosa	Piperacillin-tazobactam resistance	14	NA	11	NA	16	NA	11	NA	16	NA	NA
	Ceftazidime resistance	13	NA	10	NA	16	NA	9	NA	16	NA	NA
	Carbapenem (imipenem/meropenem) resistance	14	NA	11	NA	16	NA	11	NA	16	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	14	NA	11	NA	15	NA	10	NA	16	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	14	NA	11	NA	16	NA	9	NA	11	NA	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	13	NA	10	NA	15	NA	8	NA	11	NA	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	10	NA	14	NA	32	96.9	37	100.0	57	94.7	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	9	NA	14	NA	32	96.9	37	100.0	57	96.5	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	10	NA	14	NA	32	81.3	37	91.9	57	89.5	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	9	NA	14	NA	32	81.3	37	91.9	57	87.7	NA
S. aureus	MRSA[d]	35	22.9	41	29.3	43	25.6	31	9.7	33	21.2	NA
S. pneumoniae	Penicillin non-wild-type[e]	4	NA	6	NA	4	NA	3	NA	4	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	4	NA	7	NA	4	NA	2	NA	4	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	4	NA	6	NA	4	NA	2	NA	4	NA	NA
E. faecalis	High-level gentamicin resistance	11	NA	5	NA	9	NA	15	NA	29	51.7[f]	NA
E. faecium	Vancomycin resistance	6	NA	6	NA	8	NA	5	NA	13	NA	NA

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Netherlands

Participating institutions

National Institute for Public Health and the Environment

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Netherlands, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	70	72	70	72	68
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	ND	ND	ND	ND	ND

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Netherlands, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	85	92	89	NA	100

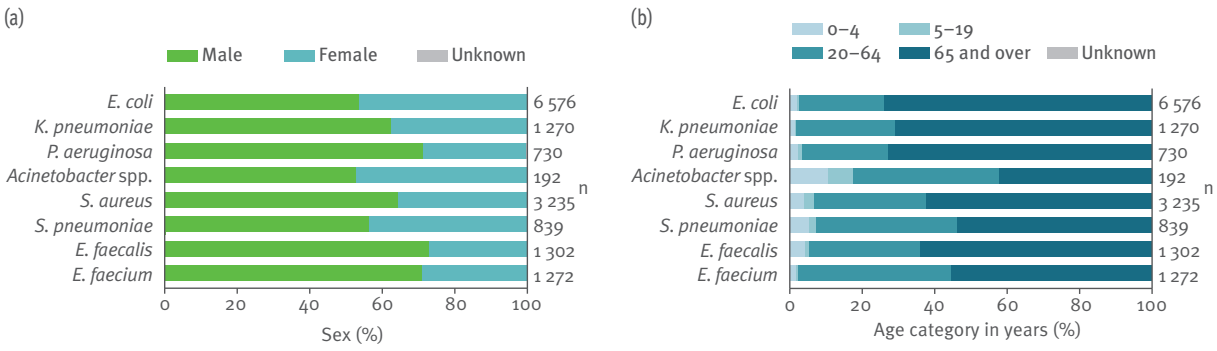
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Netherlands, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	37	7515	6	39	8276	5	35	7302	5	38	7498	4	35	6576	3
K. pneumoniae	37	1330	10	39	1521	7	35	1434	7	38	1397	6	35	1270	5
P. aeruginosa	37	738	14	39	808	11	35	683	12	37	749	11	35	730	13
Acinetobacter spp.	34	132	16	36	149	14	31	127	13	34	153	11	33	192	13
S. aureus	37	3045	9	39	3568	9	35	3221	9	38	3294	8	35	3235	9
S. pneumoniae	37	1708	9	39	1938	8	35	1552	7	38	997	6	35	839	6
E. faecalis	37	1014	15	39	1087	15	35	984	14	38	1211	24	35	1302	29
E. faecium	37	882	39	39	1008	35	35	789	37	37	1312	53	35	1272	54

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Netherlands, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Netherlands, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	7512	46.0	8272	46.0	7301	45.4	7494	42.7	6571	41.4	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	7509	6.4	8270	7.3	7300	7.5	7494	6.6	6575	6.6	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	7506	0.0	8272	0.0	7299	0.0	7487	0.0	6569	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	7511	14.4	8274	14.7	7298	14.6	7490	13.3	6575	13.3	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	7512	5.9	8275	6.3	7301	7.0	7495	6.4	6576	6.0	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	7504	2.1	8268	2.2	7296	2.6	7486	1.9	6574	2.0	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1329	10.9	1520	10.7	1434	9.6	1397	11.2	1270	10.1	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	1330	0.5	1520	0.5	1433	0.2	1396	0.1	1270	0.2	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1330	11.7	1521	11.6	1432	11.1	1395	13.1	1270	10.2	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1330	7.4	1521	7.0	1434	6.0	1397	7.3	1270	5.6	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1329	4.7	1520	4.4	1432	3.5	1395	4.3	1270	4.3	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	696	7.0	764	6.2	621	5.8	701	6.1	699	5.4	18.7 (0.0–47.2)	–
	Ceftazidime resistance	738	3.5	805	2.7	662	3.5	748	2.9	728	2.7	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	736	4.5	805	5.1	682	5.1	746	3.6	730	5.2	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	738	9.1	808	8.9	682	10.4	749	9.1	730	7.9	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	738	3.7	808	2.4	683	1.6	748	1.1	728	0.4	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	694	2.2	760	1.8	598	1.7	697	1.9	696	0.9	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	130	0.8	148	4.7	124	0.8	148	0.7	185	0.5	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	132	3.0	149	7.4	127	7.9	147	4.1	186	3.8	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	130	3.1	148	4.7	124	3.2	149	1.3	191	4.2	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	129	0.8	147	4.8	122	0.8	139	0.0	179	0.0	36.8 (0.0–98.5)	↓*
S. aureus	MRSA[f]	3045	1.6	3566	1.2	3221	1.5	3293	1.5	3231	1.5	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	1532	3.4	1713	3.0	1360	4.0	799	4.8	648	6.2	16.3 (3.6–35.7)	↑*
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	1597	5.1	1806	3.9	1406	4.8	919	3.5	766	3.3	18.3 (0.0–36.0)	↓
	Combined penicillin non-wild-type and resistance to macrolides[g]	1422	1.0	1583	0.9	1215	1.3	722	0.8	575	0.9	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	708	23.6	757	22.5	604	20.0	544	29.6	641	36.8	29.0 (6.7–55.2)	↑*
E. faecium	Vancomycin resistance	881	1.4	1006	1.3	786	0.9	1310	0.5	1272	0.3	17.2 (0.0–66.4)	↓*

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

North Macedonia

Participating institutions

Department for Microbiology, Institute of Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, North Macedonia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	100	100	100	100
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Low	Low	Low	Low	Low
Blood culture sets/1 000 patient days[a]	3 (0–37)	4 (0–40)	ND	ND	ND

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, North Macedonia, 2017–2021

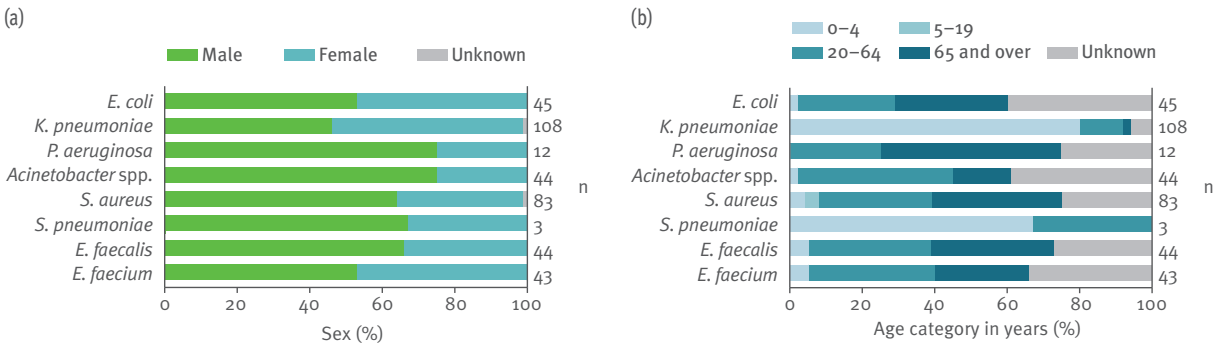
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	87	94	94	94	100
Percentage of laboratories participating in CAESAR EQA	63	94	78	92	100

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, North Macedonia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	5	77	0	7	54	6	11	82	10	9	50	16	7	45	7
K. pneumoniae	7	24	27[c]	8	39	23	5	55	36	6	118	82	5	108	71
P. aeruginosa	7	17	NA	3	11	NA	4	21	10[c]	2	9	NA	3	12	NA
Acinetobacter spp.	6	29	31[c]	3	27	30[c]	4	37	14	5	39	43	3	44	39
S. aureus	8	52	8	9	62	3	11	87	3	11	84	6	7	83	3
S. pneumoniae	1	6	NA	4	5	NA	4	14	NA	2	3	NA	3	3	NA
E. faecalis	6	21	10[c]	6	36	6	7	41	5	6	25	4[c]	9	44	12
E. faecium	5	29	4[c]	3	30	13	5	30	14	5	21	5[c]	6	43	21

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, North Macedonia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, North Macedonia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	35	82.9	53	96.2	66	87.9	48	93.7	27	96.3[f]	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	76	71.1	53	79.2	82	62.2	50	86.0	45	60.0	NA
	Carbapenem (imipenem/meropenem) resistance	77	0.0	54	3.7	82	1.2	50	2.0	45	0.0	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	77	62.3	54	74.1	80	58.7	50	70.0	45	57.8	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	76	50.0	53	50.9	82	39.0	50	48.0	45	26.7	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	75	38.7	52	40.4	80	23.8	50	28.0	45	15.6	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	23	82.6[f]	39	94.9	55	92.7	118	99.2	108	88.9	NA
	Carbapenem (imipenem/meropenem) resistance	23	17.4[f]	39	20.5	55	7.3	118	5.1	108	4.6	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	23	69.6[f]	39	87.2	55	87.3	118	75.4	108	59.3	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	23	78.3[f]	38	89.5	55	96.4	118	97.5	105	88.6	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	23	69.6[f]	38	78.9	55	85.5	118	73.7	105	53.3	NA
P. aeruginosa	Piperacillin-tazobactam resistance	17	NA	10	NA	21	19.0[f]	8	NA	12	NA	NA
	Ceftazidime resistance	17	NA	11	NA	21	23.8[f]	9	NA	12	NA	NA
	Carbapenem (imipenem/meropenem) resistance	17	NA	11	NA	21	14.3[f]	9	NA	12	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	17	NA	11	NA	21	38.1[f]	9	NA	12	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	17	NA	11	NA	20	30.0[f]	8	NA	11	NA	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	17	NA	10	NA	20	25.0[f]	7	NA	11	NA	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	28	82.1[f]	27	77.8[f]	37	89.2	39	97.4	44	97.7	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	29	79.3[f]	27	96.3[f]	37	97.3	39	97.4	43	97.7	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	28	82.1[f]	27	88.9[f]	37	73.0	39	84.6	44	95.5	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	28	75.0[f]	27	74.1[f]	37	73.0	39	84.6	43	95.3	NA
S. aureus	MRSA[d]	49	53.1	61	54.1	87	44.8	83	43.4	83	43.4	NA
S. pneumoniae	Penicillin non-wild-type[e]	6	NA	5	NA	14	NA	3	NA	3	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	6	NA	5	NA	14	NA	3	NA	3	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	6	NA	5	NA	14	NA	3	NA	3	NA	NA
E. faecalis	High-level gentamicin resistance	14	NA	30	76.7	35	54.3	16	NA	39	53.8	NA
E. faecium	Vancomycin resistance	29	51.7[f]	30	56.7	28	64.3[f]	21	66.7[f]	43	74.4	NA

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Norway

Participating institutions

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

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Norway, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	100	94	94	94	94
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	ND	47.4	86.8	91.9	87.4

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA,Norway, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	89	89	NA	93

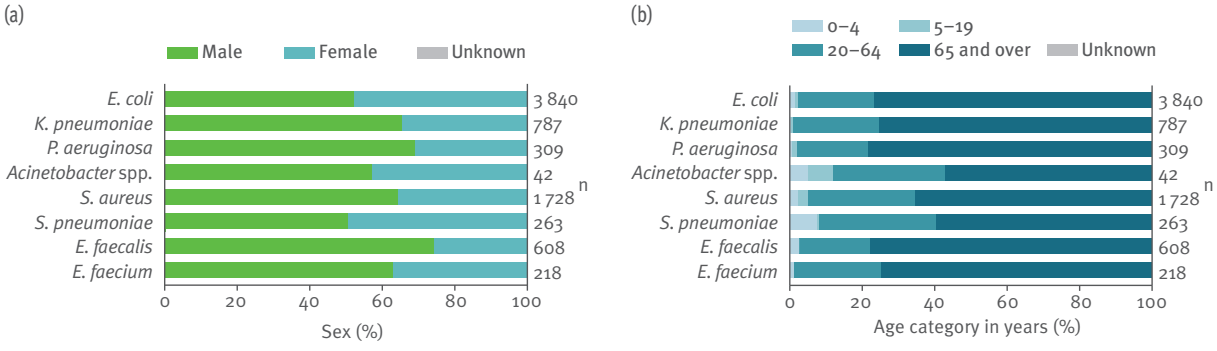
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Norway, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	18	3734	4	18	3880	3	18	4075	3	18	3764	4	18	3840	3
K. pneumoniae	18	781	5	18	738	5	18	832	5	18	703	5	18	787	3
P. aeruginosa	18	205	5	18	250	5	18	296	4	18	283	5	18	309	3
Acinetobacter spp.	12	31	10	11	32	13	12	23	5[c]	10	31	0	14	42	5
S. aureus	18	1507	6	18	1630	6	18	1723	6	18	1605	6	18	1728	6
S. pneumoniae	18	482	6	18	506	6	18	507	5	18	243	3	18	263	3
E. faecalis	18	526	7	18	525	6	18	551	6	18	546	6	18	608	6
E. faecium	18	209	10	18	174	10	18	197	7	17	183	6	18	218	11

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Norway, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Norway, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	3731	42.2	3880	42.3	4072	41.0	3758	39.8	3837	35.4	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	3734	5.9	3879	6.8	4075	6.2	3762	5.8	3839	5.5	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	3733	0.1	3879	0.0	4040	0.0	3646	0.0	3820	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	3731	13.6	3877	12.9	4068	11.3	3735	10.0	3827	9.9	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	3732	7.2	3880	5.7	4074	5.6	3763	5.7	3839	5.4	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	3729	2.4	3876	2.0	4068	1.7	3734	1.6	3826	1.6	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	781	5.8	737	7.5	832	7.7	702	10.1	787	7.4	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	781	0.0	736	0.1	826	0.2	687	0.1	783	0.3	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	781	10.2	735	13.1	832	8.8	696	11.2	782	11.8	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	781	4.2	737	5.3	831	6.1	702	7.3	786	5.1	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	781	3.2	735	3.8	831	3.9	696	4.7	782	2.9	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	183	6.0	227	5.7	270	4.1	254	5.9	278	5.8	18.7 (0.0–47.2)	–
	Ceftazidime resistance	197	5.1	240	6.3	282	3.9	277	5.4	295	6.4	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	205	3.4	250	4.8	296	7.4	282	6.4	309	6.8	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	205	4.9	250	10.4	296	5.7	282	8.5	309	4.2	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	183	0.5	236	0.8	292	0.3	281	0.4	308	0.0	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	153	2.0	204	2.9	252	2.0	246	2.8	263	2.7	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	31	0.0	32	0.0	23	0.0[h]	31	0.0	42	0.0	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	31	0.0	32	0.0	23	0.0[h]	31	0.0	42	4.8	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	31	0.0	32	0.0	23	4.3[h]	30	0.0	42	2.4	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	31	0.0	32	0.0	23	0.0[h]	30	0.0	42	0.0	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	1462	1.0	1547	0.9	1644	1.0	1552	1.6	1638	0.9	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	480	4.8	500	5.0	504	6.3	242	7.4	262	6.1	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	439	5.5	460	7.6	459	5.7	215	5.1	242	5.4	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	439	2.5	454	3.5	457	3.5	214	2.8	241	3.3	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	216	14.4	216	13.4	182	12.1	161	12.4	159	9.4	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	202	4.5	171	2.3	196	1.0	180	0.6	216	0.5	17.2 (0.0–66.4)	↓*

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.
[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Poland

Participating institutions

National Medicines Institute, Department of Epidemiology and Clinical Microbiology
National Reference Centre for Susceptibility Testing

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Poland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	19	17	17	16	20
Geographical representativeness	Medium/High	Medium	Medium	Medium	Medium
Hospital representativeness	High	Medium	Medium	Medium	Medium
Isolate representativeness	High	Medium	Medium	Medium	High
Blood culture sets/1 000 patient days	38.1	38.6	39.8	45.6	54.7

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Poland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	96	93	98	NA	98

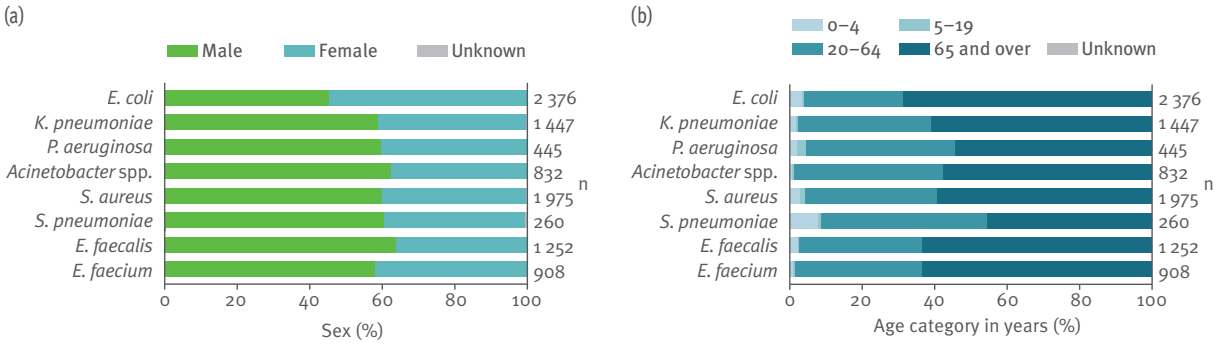
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Poland, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	65	2881	30	55	2627	27	54	2809	31	49	2179	25	52	2376	28
K. pneumoniae	65	1203	43	53	1221	47	55	1172	45	49	1091	35	52	1447	47
P. aeruginosa	64	417	46	54	394	45	54	421	40	48	317	38	49	445	49
Acinetobacter spp.	56	352	60	48	290	63	46	319	64	44	373	55	50	832	69
S. aureus	66	1848	33	57	1986	30	55	1843	34	50	1676	29	52	1975	32
S. pneumoniae	60	374	30	53	369	28	49	364	29	40	165	33	47	260	35
E. faecalis	65	758	48	53	733	43	53	773	48	49	790	36	51	1252	50
E. faecium	60	410	44	49	385	44	53	443	43	48	529	38	52	908	52

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Poland, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Poland, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	913	69.4	890	64.3	836	61.6	502	56.2	809	60.6	53.1 (31.7–70.2)	↓
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	2866	16.7	2620	17.6	2803	17.1	2172	17.4	2371	18.7	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	2741	0.0	2500	0.1	2683	0.0	2080	0.0	2290	0.1	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1832	35.9	2567	34.7	2753	33.0	2149	33.0	2268	33.1	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	2719	14.0	2449	15.1	2614	12.6	2033	14.5	2186	13.7	9.6 (4.1–27.0)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1666	8.2	2386	10.5	2564	9.3	1998	9.4	2077	10.2	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1203	63.0	1219	64.6	1166	58.3	1088	63.0	1432	70.0	34.3 (3.4–81.4)	↑*
	Carbapenem (imipenem/meropenem) resistance	1161	6.4	1183	8.1	1155	7.7	1074	8.2	1429	19.5	11.7 (0.0–73.7)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	739	66.3	1207	68.2	1159	61.3	1085	65.2	1428	70.4	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1165	55.5	1178	54.2	1128	47.5	1019	50.0	1364	55.1	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	703	52.6	1162	51.5	1112	45.0	1012	47.4	1333	53.5	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	374	31.0	366	34.4	409	26.4	266	32.3	440	27.3	18.7 (0.0–47.2)	–
	Ceftazidime resistance	415	24.6	390	26.9	418	20.1	312	21.8	442	20.4	15.8 (2.3–46.0)	↓
	Carbapenem (imipenem/meropenem) resistance	393	24.2	374	33.2	409	24.4	316	28.5	440	28.0	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	358	37.2	389	39.1	417	34.1	270	32.6	443	32.3	18.7 (3.3–48.0)	↓
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	384	25.5	384	26.0	402	19.7	239	19.7	323	12.1	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	261	19.9	332	30.1	379	23.7	178	30.9	318	23.3	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	344	67.4	278	67.3	317	71.0	372	78.2	826	82.7	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	348	83.0	268	86.9	304	85.5	366	88.3	816	92.6	43.0 (1.5–99.8)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	344	72.7	285	67.4	315	70.8	363	70.8	812	74.1	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	333	59.5	251	62.9	299	63.2	355	64.2	791	67.0	36.8 (0.0–98.5)	↑
S. aureus	MRSA[f]	1805	15.2	1959	15.9	1841	14.9	1351	13.8	1718	16.5	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	290	16.6	343	15.7	310	15.5	158	10.8	256	18.8	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	253	24.5	309	24.9	312	25.0	123	22.8	213	29.1	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	241	14.1	285	10.9	268	13.4	116	9.5	209	14.8	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	660	41.2	645	41.6	706	40.2	703	51.6	1153	55.2	29.0 (6.7–55.2)	↑*
E. faecium	Vancomycin resistance	400	31.5	374	35.8	432	44.0	527	38.5	900	34.3	17.2 (0.0–66.4)	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Portugal

Participating institutions

National Institute of Health Doutor Ricardo Jorge
Ministry of Health Directorate-General of Health
Directorate-General of Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Portugal, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	97	97	97	97	97
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	148.1	206.9	244.2	244.2	256.0

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Portugal, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	98	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	88	83	93	NA	81

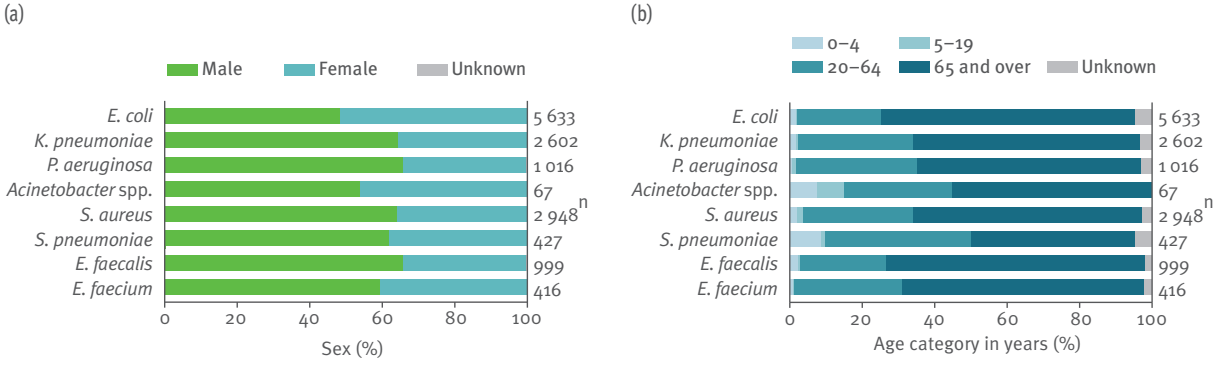
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Portugal, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	62	6452	4	59	5921	4	58	6433	4	63	5858	4	57	5633	4
K. pneumoniae	61	2743	10	58	2604	10	55	2709	9	60	2790	9	56	2602	14
P. aeruginosa	57	1220	13	55	1115	12	54	1061	11	57	1061	9	53	1016	14
Acinetobacter spp.	36	174	16	39	127	18	30	99	14	31	104	9	26	67	17
S. aureus	64	3789	5	59	3940	7	59	3308	6	65	3319	6	59	2948	10
S. pneumoniae	54	1056	1	55	1062	NA	53	983	NA	48	588	NA	41	427	NA
E. faecalis	58	1014	8	56	979	9	54	945	9	58	990	10	52	999	13
E. faecium	46	467	16	47	440	16	43	411	15	43	406	12	43	416	17

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Portugal, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Portugal, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	6 245	56.2	5895	55.1	5933	58.5	5849	54.4	5164	52.7	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	6441	15.6	5881	14.7	6390	16.1	5793	14.4	5615	13.1	13.8 (5.5–37.3)	↓*
	Carbapenem (imipenem/meropenem) resistance	6384	0.3	5797	0.5	6372	0.1	5833	0.2	5466	0.3	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	6424	27.3	5868	25.5	6431	26.5	5845	23.9	5618	22.5	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	6387	11.9	5825	12.2	6428	12.1	5788	11.7	5605	10.6	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	6365	6.6	5746	6.2	6384	6.3	5716	6.1	5591	5.1	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	2743	44.9	2579	50.0	2697	47.6	2762	47.6	2581	45.0	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	2720	8.6	2563	11.7	2690	10.9	2780	11.6	2520	11.6	11.7 (0.0–73.7)	↑
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	2736	45.7	2592	43.8	2704	45.8	2779	42.7	2596	41.6	33.6 (0.0–80.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	2717	33.5	2572	34.4	2708	32.2	2759	28.2	2592	25.0	23.7 (0.0–69.1)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	2711	28.4	2538	26.7	2692	26.5	2734	23.8	2571	20.6	21.2 (0.0–67.4)	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	1206	24.2	1096	21.9	1054	20.3	1060	17.5	985	16.4	18.7 (0.0–47.2)	↓*
	Ceftazidime resistance	1216	18.6	1090	18.6	1054	17.6	977	14.4	1013	15.2	15.8 (2.3–46.0)	↓*
	Carbapenem (imipenem/meropenem) resistance	1215	18.3	1108	15.7	1052	17.8	1057	13.4	1015	14.1	18.1 (3.5–45.9)	↓*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1208	23.7	1104	23.7	1057	21.6	1059	18.5	1012	18.1	18.7 (3.3–48.0)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	1210	12.1	1109	11.9	1060	9.9	877	5.4	875	6.3	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	1194	16.1	1075	15.4	1043	14.2	794	9.8	872	12.7	12.6 (0.0–42.1)	↓*
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	172	40.7	127	30.7	90	31.1	104	15.4	67	10.4	39.9 (0.0–99.5)	↓*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	172	38.4	123	34.1	88	26.1	101	17.8	62	17.7	43.0 (1.5–99.8)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	168	28.6	126	25.4	93	24.7	104	12.5	64	12.5	39.6 (2.1–98.8)	↓*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	166	24.1	123	22.0	83	20.5	101	8.9	59	8.5	36.8 (0.0–98.5)	↓*
S. aureus	MRSA[f]	3728	39.2	3810	38.1	3265	34.8	3299	29.7	2873	25.1	15.8 (0.9–42.9)	↓*
S. pneumoniae	Penicillin non-wild-type[g]	997	12.8	986	13.4	887	13.9	513	13.8	369	14.4	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	1024	14.8	985	15.5	952	12.8	565	15.6	404	19.1	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	978	7.1	922	8.0	865	7.5	492	8.5	348	9.8	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	931	25.8	778	26.6	881	22.2	862	19.8	802	18.2	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	461	7.2	436	4.4	410	9.0	399	7.8	409	8.6	17.2 (0.0–66.4)	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Romania

Participating institutions

National Institute of Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Romania, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	11	11	13	6
Geographical representativeness	ND	Low	Low	Low	Low
Hospital representativeness	ND	Low	Low	Low	Low
Isolate representativeness	ND	Low	Low	Low	Low
Blood culture sets/1 000 patient days	ND	34.0	20.5	26.4	32.7

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Romania, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	38	69	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	93	93	100	NA	100

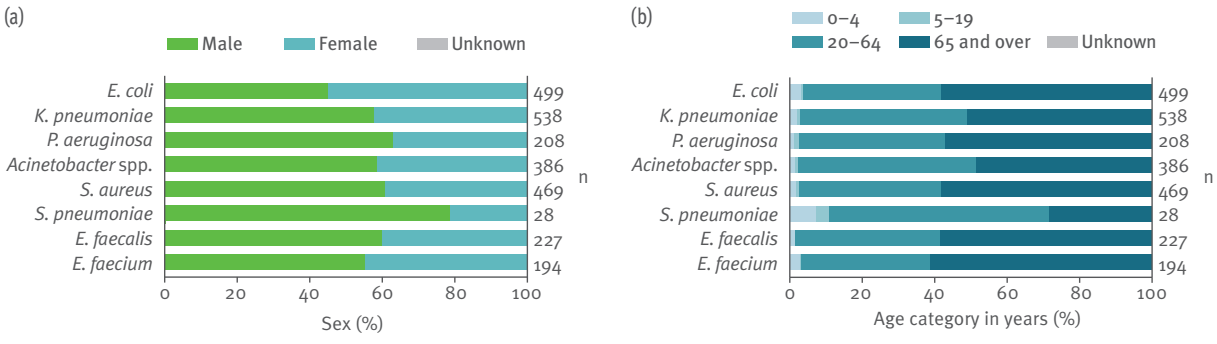
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Romania, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	14	518	14	17	654	13	15	671	12	15	455	17	16	499	18
K. pneumoniae	14	339	43	17	443	44	15	488	43	16	478	54	16	538	52
P. aeruginosa	14	132	46	17	156	40	14	192	44	15	148	53	16	208	51
Acinetobacter spp.	12	183	73	17	218	73	15	268	75	15	298	72	16	386	73
S. aureus	14	535	23	17	626	24	14	634	23	16	418	30	16	469	27
S. pneumoniae	11	81	22	12	93	24	11	107	15	11	42	20	10	28	23[c]
E. faecalis	14	128	37	17	178	25	14	166	35	15	167	58	16	227	47
E. faecium	13	64	45	15	79	43	14	144	48	16	122	53	14	194	53

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Romania, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Romania, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	494	68.2	542	62.2	538	63.0	316	62.7	352	64.2	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	518	18.7	654	20.2	664	20.3	452	19.7	495	18.8	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	510	0.4	653	0.0	666	0.6	454	0.7	498	0.4	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	518	26.4	646	29.1	654	28.3	450	26.0	498	24.7	21.9 (9.6–51.6)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	513	15.2	649	12.8	594	11.6	367	10.9	406	10.6	9.6 (4.1–27.0)	⇩*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	513	9.7	641	7.2	576	7.3	360	5.8	401	5.0	5.1 (1.2–14.8)	⇩*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	339	62.5	443	61.4	479	64.1	477	67.9	534	70.8	34.3 (3.4–81.4)	⇧*
	Carbapenem (imipenem/meropenem) resistance	334	22.5	441	29.5	470	32.3	474	48.3	538	54.5	11.7 (0.0–73.7)	⇧*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	337	64.1	441	57.4	471	62.0	474	66.2	536	67.2	33.6 (0.0–80.0)	⇧*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	338	58.6	436	50.9	411	53.0	399	49.6	440	51.6	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	336	55.4	434	46.3	402	52.0	397	47.9	434	48.4	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	131	52.7	135	45.9	178	52.8	121	42.1	195	47.2	18.7 (0.0–47.2)	–
	Ceftazidime resistance	127	55.9	152	46.7	180	52.2	144	41.0	202	46.0	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	131	63.4	156	55.1	184	55.4	148	43.9	207	45.9	18.1 (3.5–45.9)	⇩*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	132	62.1	155	52.3	184	52.2	140	46.4	204	45.1	18.7 (3.3–48.0)	⇩*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	132	57.6	146	50.7	176	48.9	124	37.1	168	41.7	8.9 (0.0–41.7)	⇩*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	126	58.7	125	48.8	159	52.2	96	41.7	159	42.1	12.6 (0.0–42.1)	⇩*
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	182	87.4	218	85.3	264	88.3	297	93.3	386	93.5	39.9 (0.0–99.5)	⇧*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	183	89.1	218	88.1	262	91.2	297	95.3	385	94.5	43.0 (1.5–99.8)	⇧*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	183	83.6	210	80.0	241	83.8	253	90.1	336	91.1	39.6 (2.1–98.8)	⇧*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	182	81.3	210	77.6	236	83.5	251	88.8	335	89.9	36.8 (0.0–98.5)	⇧*
S. aureus	MRSA[f]	507	45.4	600	43.0	625	46.9	406	47.3	461	41.0	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	79	29.1	90	40.0	86	19.8	39	38.5	28	35.7[h]	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	76	26.3	93	32.3	92	17.4	37	27.0	25	36.0[h]	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	75	24.0	90	26.7	74	9.5	34	23.5	25	28.0[h]	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	89	44.9	168	37.5	155	40.6	148	43.2	212	37.3	29.0 (6.7–55.2)	–
E. faecium	Vancomycin resistance	64	34.4	77	40.3	140	35.7	112	39.3	191	44.5	17.2 (0.0–66.4)	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ⇧ and ⇩ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.
[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Russia

Participating institutions

Institute of Antimicrobial Chemotherapy, Smolensk State Medical Academy

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Russia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	ND	ND	ND
Geographical representativeness	High	High	High	High	High
Hospital representativeness	Poor	Poor	Poor	Poor	Poor
Isolate representativeness	Poor	Poor	Poor	Poor	Poor
Blood culture sets/1 000 patient days[a]	10 (0–50)	6 (1–86)	15 (12–55)	11 (1–21)	16 (1–46)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Russia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	ND	ND	100	100	100
Percentage of laboratories participating in CAESAR EQA	ND	72	0	100	NA

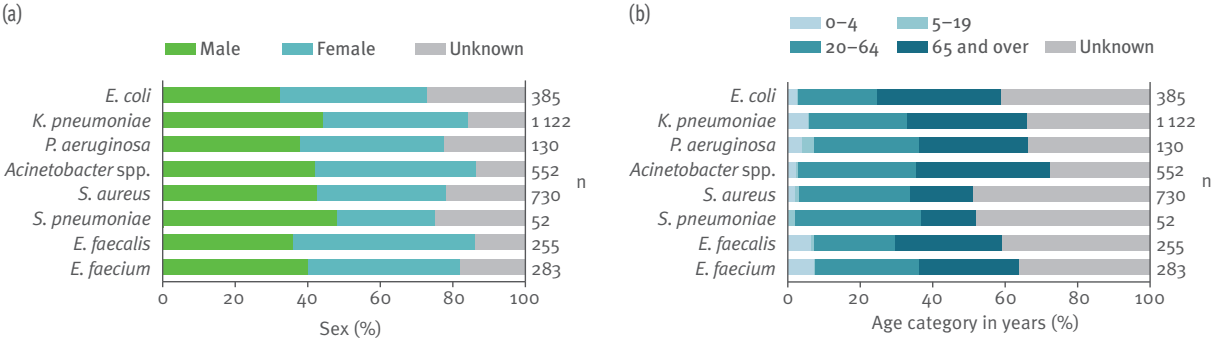
ND: no data available.
NA: not applicable.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Russia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	18	52	50	25	82	50	13	216	61	13	154	58	24	385	38
K. pneumoniae	24	127	69	23	170	81	13	418	74	15	546	80	26	1122	57
P. aeruginosa	16	45	64	18	50	76	10	76	71	12	62	69	23	130	49
Acinetobacter spp.	15	51	84	17	81	75	11	178	76	15	267	88	23	552	62
S. aureus	20	85	53	19	107	45	12	333	47	15	317	58	25	730	38
S. pneumoniae	11	18	NA	ND	ND	ND	8	23	43[c]	6	13	ND	12	52	44
E. faecalis	8	27	30[c]	10	27	59[c]	13	100	46	14	131	66	20	255	59
E. faecium	6	14	NA	7	19	NA	11	63	49	12	127	93	25	283	35

Labs: laboratories.
NA: not applicable.
ND: no data available.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Russia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Russia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	52	86.5	82	87.8	121	65.3	76	80.3	189	82.0	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	52	73.1	82	65.9	207	47.8	147	52.4	376	52.1	NA
	Carbapenem (imipenem/meropenem) resistance	52	0.0	82	0.0	210	1.9	150	4.0	373	7.5	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	52	59.6	82	62.2	207	50.2	146	58.2	340	54.7	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	52	42.3	82	31.7	143	25.2	100	33.0	284	26.8	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	52	36.5	82	23.2	133	24.8	87	32.2	279	20.1	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	127	90.6	170	83.5	389	81.0	524	89.7	1098	87.9	NA
	Carbapenem (imipenem/meropenem) resistance	127	21.3	170	30.6	415	47.0	542	64.8	1107	65.9	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	125	80.0	170	87.1	407	82.8	535	89.2	977	87.3	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	127	81.1	170	83.5	295	61.7	473	75.5	792	67.8	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	125	76.0	170	75.3	283	57.2	449	75.5	764	72.1	NA
P. aeruginosa	Piperacillin-tazobactam resistance	45	64.4	49	40.8	23	43.5[f]	36	50.0	61	39.3	NA
	Ceftazidime resistance	45	57.8	49	38.8	68	42.6	60	50.0	123	43.1	NA
	Carbapenem (imipenem/meropenem) resistance	45	51.1	49	53.1	76	52.6	60	48.3	129	52.7	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	45	64.4	49	42.9	75	42.7	60	48.3	124	50.8	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	45	60.0	49	36.7	45	42.2	29	44.8[f]	73	38.4	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	45	62.2	49	40.8	10	NA	26	46.2[f]	48	41.7	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	51	92.2	81	79.0	174	78.2	263	93.9	552	88.0	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	51	94.1	81	97.5	173	80.9	263	94.7	415	90.1	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	51	90.2	81	88.9	106	88.7	217	89.9	328	78.4	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	51	84.3	81	70.4	104	86.5	215	89.3	320	75.0	NA
S. aureus	MRSA[d]	85	16.5	107	14.0	320	23.1	305	24.6	716	14.0	NA
S. pneumoniae	Penicillin non-wild-type[e]	18	NA	ND	ND	22	13.6[f]	13	NA	36	5.6	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	18	NA	ND	ND	21	38.1[f]	10	NA	44	22.7	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	18	NA	ND	ND	20	5.0[f]	10	NA	29	0.0[f]	NA
E. faecalis	High-level gentamicin resistance	27	55.6[f]	27	40.7[f]	77	39.0	50	38.0	99	85.9	NA
E. faecium	Vancomycin resistance	14	NA	19	NA	62	4.8	127	11.8	253	24.5	NA

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (› 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Serbia

Participating institutions

Department of Clinical Microbiology with the Reference Laboratory for Bacterial Resistance to Antimicrobials, Centre for Microbiology, Institute of Public Health of Vojvodina, Novi Sad

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Serbia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	75	78	78	78	78
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Medium	Medium	Medium	Medium	Medium
Blood culture sets/1 000 patient days[a]	15 (0–82)	16 (1–85)	17 (1–88)	17 (1–111)	23 (1–117)

Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Serbia, 2017–2021

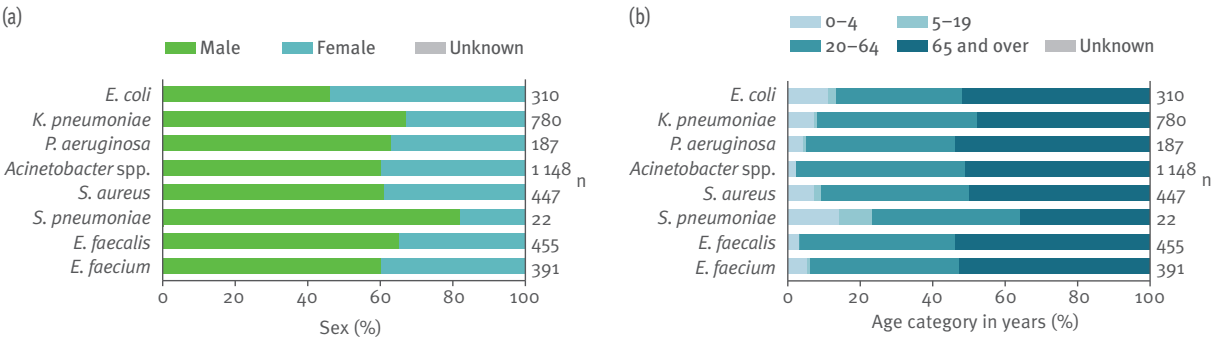
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100	100	100
Percentage of laboratories participating in CAESAR EQA	100	100	96	100	100

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Serbia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	20	399	10	23	438	9	23	510	11	23	285	11	24	310	11
K. pneumoniae	20	416	24	23	511	25	21	513	18	22	387	28	22	780	45
P. aeruginosa	18	134	21	22	177	27	20	196	28	21	129	25	19	187	44
Acinetobacter spp.	20	429	39	23	516	32	22	532	41	21	702	48	23	1148	76
S. aureus	22	542	14	24	616	13	24	628	14	21	391	13	23	447	23
S. pneumoniae	14	86	17	18	79	10	16	85	9	11	27	26[c]	9	22	18[c]
E. faecalis	20	208	19	23	261	18	22	272	24	22	312	37	23	455	55
E. faecium	15	112	23	19	154	18	22	159	22	21	276	35	22	391	66

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Serbia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Serbia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	365	63.0	416	67.3	474	63.9	275	68.0	295	70.8	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	399	29.3	437	28.1	509	25.3	284	28.5	310	35.5	–
	Carbapenem (imipenem/meropenem) resistance	399	1.0	437	0.9	502	0.4	284	1.4	310	3.2	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	394	40.4	436	39.2	509	34.8	283	36.7	307	45.3	–
	Aminoglycoside (gentamicin/tobramycin) resistance	382	34.6	432	28.0	491	30.3	278	45.3	301	42.5	↑*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	377	20.7	429	17.0	489	13.1	276	14.5	298	18.8	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	416	85.8	511	85.5	512	87.7	387	87.3	768	91.9	↑*
	Carbapenem (imipenem/meropenem) resistance	416	34.9	511	36.2	512	39.3	384	47.9	775	62.7	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	407	75.9	509	72.7	508	78.0	383	76.8	773	89.1	↑*
	Aminoglycoside (gentamicin/tobramycin) resistance	393	75.8	502	69.7	466	77.3	357	85.4	691	77.7	↑*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	384	64.3	500	58.6	461	65.1	354	69.2	686	71.7	↑*
P. aeruginosa	Piperacillin-tazobactam resistance	125	44.0	176	52.3	191	53.9	128	59.4	185	53.0	–
	Ceftazidime resistance	130	55.4	176	57.4	195	59.5	129	63.6	184	60.3	–
	Carbapenem (imipenem/meropenem) resistance	133	48.9	177	55.9	195	55.4	128	69.5	187	62.6	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	134	56.7	177	58.8	194	59.3	127	70.1	185	67.6	↑*
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	132	59.8	177	58.8	195	58.5	90	58.9	142	49.3	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	121	51.2	175	56.0	188	56.4	88	61.4	137	53.3	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	429	95.1	516	95.9	532	96.1	699	98.6	1145	98.0	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	428	96.0	515	96.7	532	97.2	702	98.9	1147	98.1	↑*
	Aminoglycoside (gentamicin/tobramycin) resistance	429	94.2	516	92.8	509	91.6	661	96.4	1128	96.0	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	428	91.8	515	91.7	509	90.2	660	95.9	1127	95.6	↑*
S. aureus	MRSA[d]	541	25.9	612	29.2	628	26.4	386	35.8	447	36.0	↑*
S. pneumoniae	Penicillin non-wild-type[e]	86	38.4	77	32.5	85	36.5	27	48.1[f]	21	47.6[f]	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	79	26.6	74	27.0	77	35.1	22	31.8[f]	22	27.3[f]	–
	Combined penicillin non-wild-type and resistance to macrolides[e]	79	22.8	72	22.2	77	26.0	22	18.2[f]	21	28.6[f]	–
E. faecalis	High-level gentamicin resistance	195	70.8	255	64.7	263	59.7	300	76.3	445	80.0	↑*
E. faecium	Vancomycin resistance	109	45.9	154	53.9	159	59.7	274	60.9	389	55.3	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[c] The aminoglycoside group includes only tobramycin from 2020 onwards.
[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.
[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Slovakia

Participating institutions

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

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Slovakia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	68	64	56	56	56
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	ND	High	High	High	High
Blood culture sets/1 000 patient days	20.8	23.7	36.1	27.0	32.1

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Slovakia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	100	NA	100

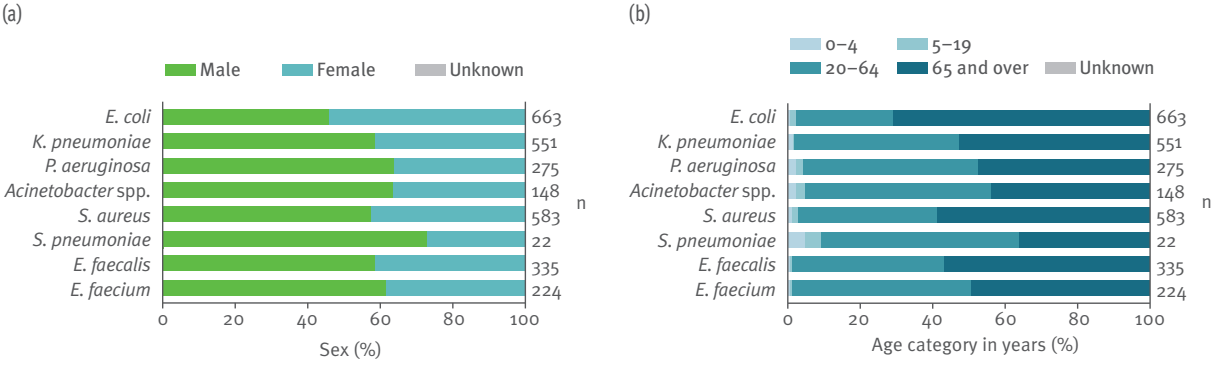
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Slovakia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	13	882	15	12	983	14	10	851	14	11	732	17	13	663	16
K. pneumoniae	13	468	32	11	505	33	10	370	26	11	405	35	13	551	41
P. aeruginosa	13	211	30	11	259	32	10	201	30	11	246	35	13	275	42
Acinetobacter spp.	13	126	39	11	146	36	8	97	44	11	95	37	12	148	57
S. aureus	13	614	21	12	627	25	10	567	18	11	540	22	13	583	20
S. pneumoniae	10	40	30	9	47	13	6	40	20	5	15	NA	6	22	18[c]
E. faecalis	13	226	29	12	256	32	10	212	32	11	199	30	12	335	42
E. faecium	11	122	32	11	168	33	10	139	32	10	121	31	12	224	52

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Slovakia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Slovakia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	853	64.9	967	61.7	849	57.8	728	57.1	660	54.5	53.1 (31.7–70.2)	⇣*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	870	30.9	973	30.1	846	23.0	727	27.1	649	23.1	13.8 (5.5–37.3)	⇣*
	Carbapenem (imipenem/meropenem) resistance	844	0.0	924	0.0	785	0.1	705	0.1	625	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	882	43.2	969	42.1	850	34.0	729	34.2	662	29.8	21.9 (9.6–51.6)	⇣*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	875	22.5	969	21.6	847	16.6	731	18.5	663	14.2	9.6 (4.1–27.0)	⇣*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	863	17.7	965	16.6	842	12.7	724	14.9	648	10.3	5.1 (1.2–14.8)	⇣*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	459	63.2	497	55.9	367	57.5	399	54.4	545	68.4	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	450	4.4	488	3.5	351	4.6	392	8.2	515	11.7	11.7 (0.0–73.7)	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	466	66.7	497	61.0	367	56.9	403	53.8	550	64.9	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	468	61.1	496	54.8	369	49.3	405	48.9	551	59.7	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	457	57.1	491	49.5	366	45.1	399	44.4	544	51.8	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	180	33.3	236	28.0	175	28.0	213	33.3	254	31.5	18.7 (0.0–47.2)	–
	Ceftazidime resistance	180	35.6	237	32.1	178	31.5	214	32.7	253	32.4	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	202	47.0	248	44.0	197	39.1	231	48.9	258	44.2	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	211	46.9	252	52.4	201	46.3	246	49.6	273	48.0	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	211	36.0	254	37.4	199	33.2	242	33.1	265	33.6	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	180	41.7	230	36.5	175	32.0	210	35.7	244	34.0	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	120	31.7	141	44.0	96	55.2	91	30.8	134	61.2	39.9 (0.0–99.5)	⇡*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	126	52.4	141	56.0	94	61.7	95	38.9	148	68.2	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	125	40.0	144	44.4	97	46.4	95	28.4	147	61.9	39.6 (2.1–98.8)	⇡
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	119	25.2	139	36.0	93	41.9	91	24.2	134	53.7	36.8 (0.0–98.5)	⇡*
S. aureus	MRSA[f]	613	29.2	610	26.6	563	27.2	540	24.8	582	22.3	15.8 (0.9–42.9)	⇣*
S. pneumoniae	Penicillin non-wild-type[g]	39	25.6	46	13.0	40	5.0	14	NA	22	9.1[h]	16.3 (3.6–35.7)	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	31	35.5	45	24.4	36	11.1	15	NA	21	14.3[h]	18.3 (0.0–36.0)	NA
	Combined penicillin non-wild-type and resistance to macrolides[g]	30	23.3	44	11.4	36	2.8	14	NA	21	4.8[h]	9.9 (0.0–28.0)	NA
E. faecalis	High-level gentamicin resistance	213	25.8	215	40.0	201	32.8	195	35.9	325	52.6	29.0 (6.7–55.2)	⇡*
E. faecium	Vancomycin resistance	122	32.0	161	32.3	137	29.2	120	40.0	219	34.7	17.2 (0.0–66.4)	–

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ⇡ and ⇣ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

[h] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

Slovenia

Participating institutions

National Institute of Public Health
Medical faculty, University of Ljubljana
National Laboratory of Health, Environment and Food

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Slovenia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	99	99	99	99	99
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	41.2	36.8	40.4	47.1	46.8

Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Slovenia, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	91	91	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	91	NA	100

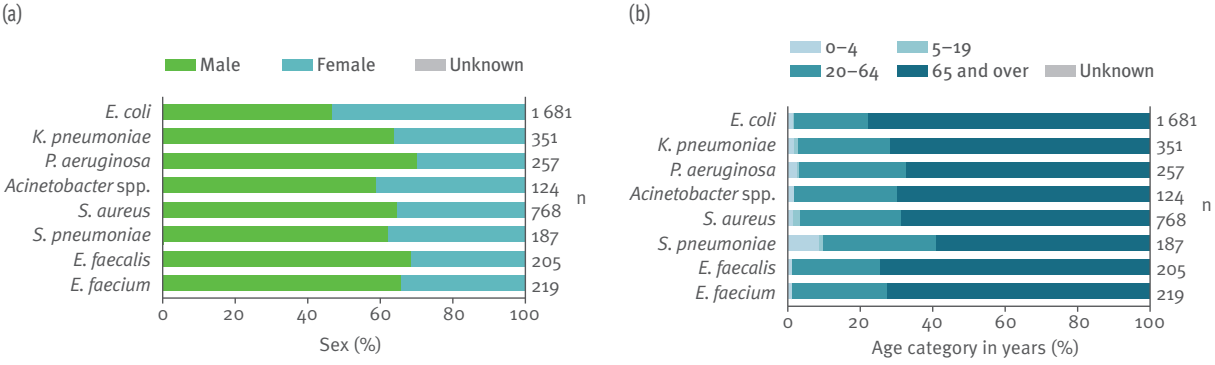
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Slovenia, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	10	1435	9	10	1668	7	10	1610	6	10	1617	6	10	1681	5
K. pneumoniae	10	312	20	10	289	14	10	303	14	10	291	17	10	351	14
P. aeruginosa	10	138	30	10	174	24	10	175	26	10	186	35	9	257	20
Acinetobacter spp.	4	36	50	8	39	33	8	40	38	7	36	39	9	124	56
S. aureus	10	576	13	10	606	9	10	656	10	10	711	14	10	768	12
S. pneumoniae	10	319	10	10	271	13	10	283	10	10	172	9	10	187	8
E. faecalis	10	171	19	10	162	15	9	141	24	9	182	15	9	205	20
E. faecium	9	149	41	9	134	32	10	137	32	9	177	32	10	219	34

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Slovenia, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Slovenia, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	1435	51.6	1668	53.5	1610	51.7	1617	51.3	1681	50.8	53.1 (31.7–70.2)	–
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1435	12.5	1668	11.3	1610	9.8	1617	10.6	1681	9.3	13.8 (5.5–37.3)	↓*
	Carbapenem (imipenem/meropenem) resistance	1435	0.0	1668	0.0	1610	0.0	1617	0.0	1681	0.0	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1383	24.9	1668	22.8	1610	19.0	1617	18.1	1681	16.7	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1435	11.4	1668	9.4	1610	7.8	1616	6.8	1681	6.6	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1383	6.3	1668	4.7	1610	4.0	1616	3.6	1681	2.8	5.1 (1.2–14.8)	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	312	23.7	289	14.9	303	16.5	291	15.8	351	21.7	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	312	0.0	289	0.7	303	0.3	291	0.0	351	0.9	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	306	30.4	289	27.3	303	19.5	291	24.7	351	24.2	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	312	16.0	289	12.8	303	8.3	290	10.0	351	13.7	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	306	16.0	289	10.0	303	7.6	290	7.6	351	12.3	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	138	13.0	174	16.1	175	14.9	186	14.5	257	14.8	18.7 (0.0–47.2)	–
	Ceftazidime resistance	138	13.0	174	14.9	175	16.0	186	13.4	257	14.4	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	138	17.4	174	14.9	175	20.0	186	13.4	257	13.2	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	123	20.3	174	21.8	175	18.9	186	15.6	257	16.7	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	138	8.7	174	6.9	175	4.0	56	3.6	174	3.4	8.9 (0.0–41.7)	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	123	11.4	174	11.5	175	12.0	56	7.1	174	10.3	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	36	41.7	39	17.9	40	22.5	36	19.4	124	66.9	39.9 (0.0–99.5)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	36	47.2	39	28.2	40	27.5	36	27.8	124	73.4	43.0 (1.5–99.8)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	36	41.7	39	20.5	40	25.0	36	25.0	124	68.5	39.6 (2.1–98.8)	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	36	41.7	39	17.9	40	20.0	36	16.7	124	66.9	36.8 (0.0–98.5)	↑*
S. aureus	MRSA[f]	576	9.0	606	11.7	656	7.5	711	9.8	768	7.8	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	319	10.0	271	9.6	283	11.0	172	13.4	187	6.4	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	216	15.7	271	10.3	283	9.9	172	14.5	187	7.0	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	216	6.5	271	4.8	283	4.9	172	7.6	187	2.1	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	167	33.5	161	20.5	138	22.5	179	18.4	196	19.4	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	149	0.7	134	0.0	137	2.9	177	1.1	219	3.7	17.2 (0.0–66.4)	↑*

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Spain

Participating institutions

Health Institute Carlos lll
National Centre for Microbiology

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Spain, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	37	31	32	36	31
Geographical representativeness	High	Medium	Medium	Medium	Medium
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	ND	57.3	67.6	109.5	165.4

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Spain, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	58	71	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	90	95	91	NA	91

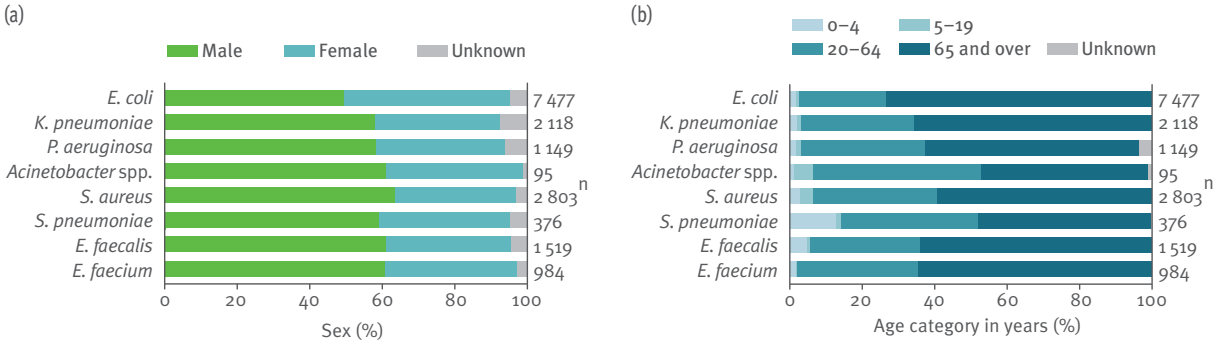
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Spain, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	37	6032	NA	39	7933	NA	39	8353	NA	43	7939	NA	38	7477	NA
K. pneumoniae	36	1514	NA	38	1995	NA	39	2403	NA	42	2244	NA	38	2118	NA
P. aeruginosa	36	869	NA	38	1122	NA	39	1108	NA	41	1228	NA	38	1149	NA
Acinetobacter spp.	22	92	NA	18	81	NA	21	83	NA	21	92	NA	24	95	NA
S. aureus	37	1925	NA	39	2531	NA	41	2719	NA	42	2542	NA	40	2803	NA
S. pneumoniae	34	752	NA	37	1033	NA	37	1038	NA	41	614	NA	36	376	NA
E. faecalis	36	969	NA	38	1163	NA	38	1301	NA	41	1531	NA	39	1519	NA
E. faecium	35	599	NA	37	769	NA	37	848	NA	42	1104	NA	38	984	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Spain, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Spain, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	5947	62.4	7599	62.9	7831	61.2	7214	57.6	6969	56.3	53.1 (31.7–70.2)	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	6027	12.8	7923	13.8	8345	14.1	7744	14.1	7319	13.2	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	6026	0.0	7924	0.0	8346	1.9	7848	0.4	6121	0.1	0.2 (0.0–1.1)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	5781	32.5	7616	32.1	8192	29.5	7799	28.6	7465	26.7	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	6029	13.7	7924	14.1	8304	13.6	7829	13.6	7461	12.4	9.6 (4.1–27.0)	↓*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	5774	5.5	7598	6.4	8138	6.3	7512	6.3	7302	5.4	5.1 (1.2–14.8)	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1513	21.3	1994	25.5	2396	25.3	2185	26.6	2071	27.9	34.3 (3.4–81.4)	↑*
	Carbapenem (imipenem/meropenem) resistance	1510	2.8	1995	3.8	2398	4.8	2228	4.6	1791	5.9	11.7 (0.0–73.7)	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1486	22.5	1927	23.8	2375	24.0	2222	25.7	2112	28.1	33.6 (0.0–80.0)	↑*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1513	17.4	1995	19.3	2370	18.2	2229	20.1	2113	20.9	23.7 (0.0–69.1)	↑*
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1484	12.8	1926	15.7	2339	15.5	2149	16.4	2065	18.2	21.2 (0.0–67.4)	↑*
P. aeruginosa	Piperacillin-tazobactam resistance	813	7.4	1076	9.1	1077	14.2	1173	11.3	1088	14.2	18.7 (0.0–47.2)	↑*
	Ceftazidime resistance	862	9.6	1087	8.7	1098	11.1	1167	9.7	1000	12.1	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	861	18.4	1120	18.5	1107	21.8	1226	16.8	1139	17.2	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	868	19.9	1102	20.1	1105	18.7	1211	18.2	1121	20.3	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	864	12.4	1121	11.6	1083	15.0	1197	8.8	1107	11.2	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	809	10.5	1023	11.1	1040	13.5	1119	9.6	944	11.4	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	92	66.3	81	54.3	83	56.6	92	60.9	93	57.0	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	92	68.5	81	56.8	82	54.9	92	62.0	93	58.1	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	92	52.2	81	49.4	83	47.0	92	53.3	93	58.1	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	92	48.9	81	44.4	82	47.6	92	51.1	92	53.3	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	1856	25.2	2444	24.7	2711	23.3	2313	23.1	1792	24.2	15.8 (0.9–42.9)	–
S. pneumoniae	Penicillin non-wild-type[g]	735	22.3	981	18.5	958	19.8	543	20.8	314	22.3	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	717	21.8	1007	18.0	975	21.0	589	22.1	358	27.4	18.3 (0.0–36.0)	↑
	Combined penicillin non-wild-type and resistance to macrolides[g]	701	12.4	957	9.6	905	10.9	527	11.8	303	13.2	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	873	36.9	1002	34.8	1051	36.7	1329	34.1	1339	31.4	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	570	1.8	764	2.5	846	1.2	1079	1.2	983	1.0	17.2 (0.0–66.4)	↓*

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).
[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.
[e] The aminoglycoside group includes only tobramycin from 2020 onwards.
[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Sweden

Participating institutions

The Public Health Agency of Sweden

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Sweden, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	57	51	78	78	89
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days	156.7	107.0	105.6	105.6	ND

ND: no data available.
Definitions provided on page 11. For data reported in 2017–2020, isolate representativeness refers to patient and isolate representativeness as defined in the report 'Antimicrobial resistance surveillance in Europe 2022 – 2020 data'.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in EARS-Net EQA, Sweden, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100[a]	100[a]	100[a]
Percentage of laboratories participating in EARS-Net EQA	100	100	95	NA	100

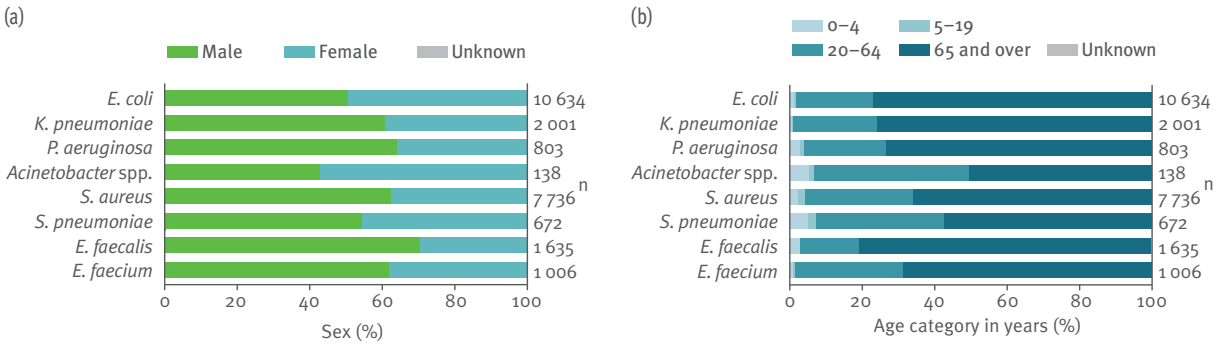
NA: not applicable. In 2020 there was no EARS-Net EQA.
[a] Starting with 2019 data, EARS-Net was restricted to laboratories using EUCAST or EUCAST-harmonised methodology and breakpoints.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Sweden, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	10	5807	NA	9	5392	NA	19	9424	NA	20	9852	NA	21	10634	NA
K. pneumoniae	10	1034	NA	9	1089	NA	19	1795	NA	20	1843	NA	21	2001	NA
P. aeruginosa	10	446	NA	9	412	NA	19	707	NA	20	735	NA	21	803	NA
Acinetobacter spp.	1	54	NA	1	55	NA	1	113	NA	1	126	NA	1	138	NA
S. aureus	11	3800	NA	9	3640	NA	20	6173	NA	20	6891	NA	21	7736	NA
S. pneumoniae	11	755	NA	9	676	NA	19	1071	NA	20	551	NA	21	672	NA
E. faecalis	11	1630	NA	9	687	NA	19	1297	NA	20	1443	NA	21	1635	NA
E. faecium	11	622	NA	9	428	NA	19	703	NA	20	789	NA	21	1006	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Sweden, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, 2021 EU/EEA range, population-weighted mean and trend, Sweden, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		2021 EU/EEA range and population-weighted mean[b]	Trend 2017–2021[c]
		n	%	n	%	n	%	n	%	n	%		
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	53.1 (31.7–70.2)	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	5790	7.4	5390	8.3	9419	7.8	9852	7.9	10633	7.1	13.8 (5.5–37.3)	–
	Carbapenem (imipenem/meropenem) resistance	5769	0.0	5388	0.0	9413	0.0	9846	0.0	10626	0.1	0.2 (0.0–1.1)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	5762	15.8	5378	18.1	9412	15.9	9798	14.1	10570	13.7	21.9 (9.6–51.6)	↓*
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	5758	6.5	5378	7.7	9410	6.0	9840	5.9	10299	6.0	9.6 (4.1–27.0)	↓
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	5746	2.0	5368	3.1	9405	2.2	9792	2.1	10247	1.9	5.1 (1.2–14.8)	↓
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1034	5.6	1089	5.5	1795	8.3	1842	8.1	2000	7.0	34.3 (3.4–81.4)	–
	Carbapenem (imipenem/meropenem) resistance	1033	0.1	1088	0.2	1793	0.1	1843	0.3	1997	0.2	11.7 (0.0–73.7)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1034	9.8	1087	10.1	1789	10.5	1830	10.2	1989	11.1	33.6 (0.0–80.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	1033	4.7	1087	3.0	1794	4.2	1839	3.6	1939	3.9	23.7 (0.0–69.1)	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides[d]	1033	3.3	1086	2.6	1789	3.2	1827	2.4	1927	2.3	21.2 (0.0–67.4)	–
P. aeruginosa	Piperacillin-tazobactam resistance	446	6.3	411	7.8	706	6.8	735	5.4	803	8.7	18.7 (0.0–47.2)	–
	Ceftazidime resistance	446	4.5	412	6.1	706	5.1	735	5.0	803	6.6	15.8 (2.3–46.0)	–
	Carbapenem (imipenem/meropenem) resistance	446	9.0	412	4.4	706	9.8	733	4.2	803	11.8	18.1 (3.5–45.9)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	445	9.0	408	7.1	706	9.2	733	7.4	803	10.7	18.7 (3.3–48.0)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[e]	444	0.9	411	1.0	707	2.3	464	0.6	562	0.7	8.9 (0.0–41.7)	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[e]	443	3.2	406	2.0	706	3.5	464	1.9	562	3.4	12.6 (0.0–42.1)	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	54	0.0	54	3.7	112	3.6	126	7.1	138	0.7	39.9 (0.0–99.5)	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	54	0.0	55	7.3	113	8.0	126	7.1	137	1.5	43.0 (1.5–99.8)	–
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance[d]	51	0.0	55	5.5	113	5.3	125	8.0	138	5.1	39.6 (2.1–98.8)	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides[d]	51	0.0	54	3.7	112	2.7	125	7.2	137	0.0	36.8 (0.0–98.5)	–
S. aureus	MRSA[f]	3787	1.2	3639	1.9	5948	1.8	6871	2.3	7733	2.0	15.8 (0.9–42.9)	↑*
S. pneumoniae	Penicillin non-wild-type[g]	750	6.1	676	5.2	1070	6.5	544	8.5	668	7.5	16.3 (3.6–35.7)	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	750	4.7	674	4.5	1069	6.5	549	6.6	669	4.8	18.3 (0.0–36.0)	–
	Combined penicillin non-wild-type and resistance to macrolides[g]	745	3.0	674	2.7	1068	3.7	542	2.8	665	2.6	9.9 (0.0–28.0)	–
E. faecalis	High-level gentamicin resistance	945	13.3	627	12.8	1225	10.0	1238	10.1	1078	6.7	29.0 (6.7–55.2)	↓*
E. faecium	Vancomycin resistance	530	0.0	428	1.4	693	1.0	600	0.2	984	0.3	17.2 (0.0–66.4)	–

ND: no data available.
NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] Lowest and highest national resistance percentage among reporting EU/EEA countries (n = 29).

[c] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; – indicates no statistically significant trend. NA: not applicable indicates that data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[d] The aminoglycoside group includes only gentamicin and tobramycin from 2020 onwards.

[e] The aminoglycoside group includes only tobramycin from 2020 onwards.

[f] MRSA is based on AST results for cefoxitin or, if unavailable, oxacillin. AST results reported for cloxacillin, dicloxacillin, flucloxacillin or meticillin are accepted as a marker for oxacillin resistance if oxacillin is not reported. If no phenotypic results are available, data from molecular confirmation tests (detection of *mecA* gene PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[g] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints in the period 2017–2018 may have used different interpretive criteria for the susceptibility categories.

Switzerland

Participating institutions

Swiss Centre for Antibiotic Resistance, Institute for Infectious Diseases, University of Bern

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Switzerland, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	80	87	86	86	89
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	High	High	High	High	High
Blood culture sets/1 000 patient days[a]	ND	ND	ND	ND	ND

Definitions provided on page 11.
ND: no data available.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Switzerland, 2017–2021

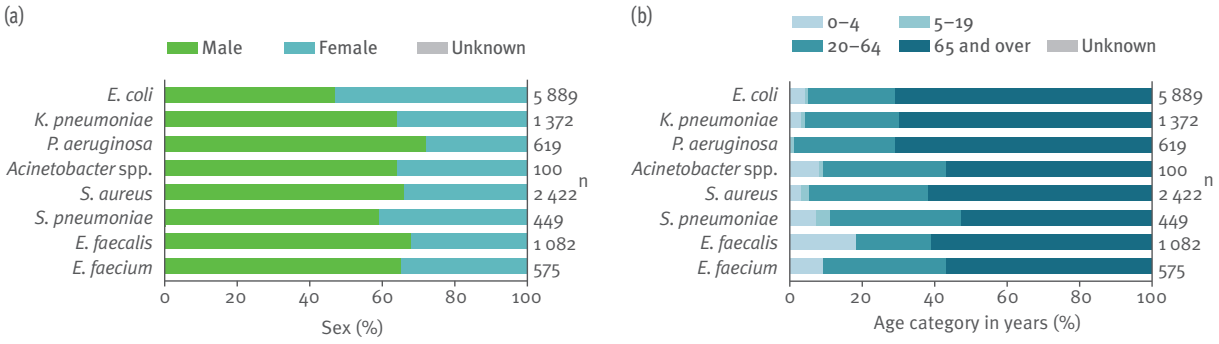
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	90	97	97	97	97
Percentage of laboratories participating in CAESAR EQA	0	0	0	64	64

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Switzerland, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	23	5400	4	29	5884	3	33	5774	3	36	5762	3	35	5889	3
K. pneumoniae	22	962	6	28	1035	7	31	1184	7	34	1236	7	34	1372	6
P. aeruginosa	23	536	9	26	522	8	31	545	8	32	609	10	31	619	11
Acinetobacter spp.	20	92	9	21	69	7	26	65	12	25	92	13	24	100	14
S. aureus	23	2027	7	29	2001	6	33	2159	7	34	2231	8	35	2422	10
S. pneumoniae	23	753	5	29	776	5	31	715	5	34	474	6	31	449	6
E. faecalis	23	676	7	29	713	8	30	737	8	34	809	12	34	1082	8
E. faecium	21	469	17	26	439	17	27	401	16	30	477	22	29	575	18

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Switzerland, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Switzerland, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	5394	49.3	5581	49.3	5407	48.6	5349	46.9	5297	46.8	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	5397	9.4	5881	10.4	5771	10.1	5753	9.9	5883	9.1	–
	Carbapenem (imipenem/meropenem) resistance	5378	0.0	5860	0.1	5734	0.0	5729	0.0	5672	0.0	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	5397	17.4	5880	17.6	5765	15.9	5752	15.6	5877	15.0	↓*
	Aminoglycoside (gentamicin/tobramycin) resistance	5388	8.2	5851	8.6	5675	8.6	5566	8.2	5276	7.7	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	5385	3.0	5848	3.5	5667	3.7	5557	2.8	5271	2.0	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	961	7.0	1034	8.6	1183	7.6	1231	6.9	1371	7.0	–
	Carbapenem (imipenem/meropenem) resistance	959	0.3	1033	1.0	1179	0.4	1227	0.3	1319	0.8	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	961	8.0	1033	10.9	1183	9.0	1236	6.8	1372	8.4	–
	Aminoglycoside (gentamicin/tobramycin) resistance	961	4.7	1033	5.5	1169	4.2	1206	3.5	1209	4.2	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	959	2.5	1030	4.5	1169	3.2	1205	1.7	1209	2.1	↓*
P. aeruginosa	Piperacillin-tazobactam resistance	536	9.0	510	11.8	521	9.8	578	8.8	586	10.9	–
	Ceftazidime resistance	510	8.4	490	9.2	522	7.9	568	6.3	587	9.2	–
	Carbapenem (imipenem/meropenem) resistance	533	8.4	522	8.6	542	10.3	607	8.4	597	10.7	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	535	8.0	519	11.0	543	10.3	604	10.9	606	10.7	–
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	535	2.6	522	4.4	543	5.2	446	1.6	495	1.8	–
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	508	3.7	478	6.9	494	5.9	441	4.8	471	6.4	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	91	9.9	69	2.9	64	3.1	90	10.0	99	10.1	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	91	14.3	69	2.9	65	7.7	91	13.2	99	13.1	–
	Aminoglycoside (gentamicin/tobramycin) resistance	89	15.7	65	4.6	63	11.1	87	12.6	93	12.9	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	89	9.0	65	3.1	63	3.2	86	10.5	92	9.8	–
S. aureus	MRSA[d]	1983	4.2	1689	4.7	2099	3.3	2157	4.5	2288	4.2	–
S. pneumoniae	Penicillin non-wild-type[e]	723	5.8	732	5.7	671	5.8	439	5.7	426	5.4	–
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	650	9.2	628	10.2	587	7.8	402	8.0	371	5.7	↓
	Combined penicillin non-wild-type and resistance to macrolides[e]	621	3.4	588	4.1	543	3.5	368	3.3	348	1.1	–
E. faecalis	High-level gentamicin resistance	273	11.0	276	5.4	413	9.9	397	12.1	426	11.0	–
E. faecium	Vancomycin resistance	465	2.2	438	3.4	399	1.8	477	3.1	573	1.9	–

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[c] The aminoglycoside group includes only tobramycin from 2020 onwards.
[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

Türkiye

Participating institutions

Ministry of Health, General Directorate of Public Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Türkiye, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	28	28	28	28	28
Geographical representativeness	High	High	High	High	High
Hospital representativeness	High	High	High	High	High
Isolate representativeness	Medium	Medium	Medium	Medium	Medium
Blood culture sets/1 000 patient days[a]	31 (4–110)	32 (4–110)	23 (1–99)	28 (2–106)	42 (3–133)

Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Türkiye, 2017–2021

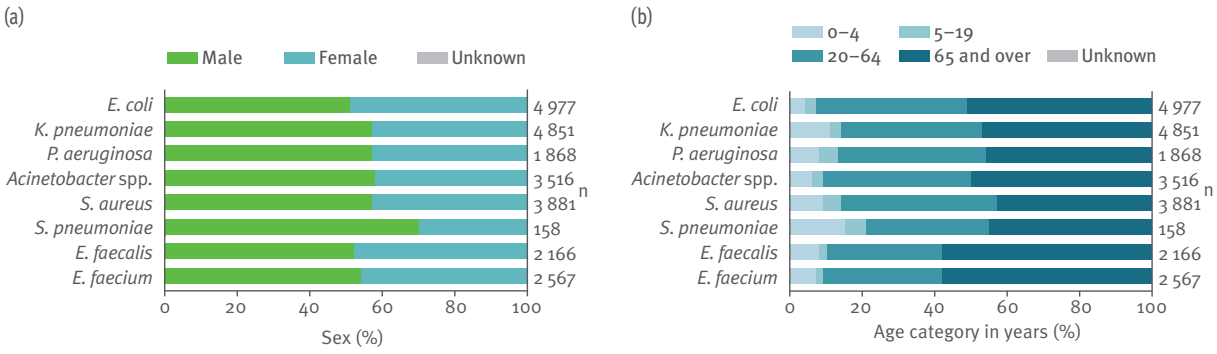
Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	100	100	100	100	100
Percentage of laboratories participating in CAESAR EQA	68	79	58	94	89

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Türkiye, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	69	4 459	16	67	5 056	13	70	4 999	12	70	4 363	14	66	4 977	26
K. pneumoniae	68	3 232	36	67	3 833	34	69	4 167	28	70	4 534	32	66	4 851	58
P. aeruginosa	66	1605	33	65	1771	31	64	1727	29	66	1556	26	65	1868	50
Acinetobacter spp.	67	2 620	45	66	2754	44	68	2 477	42	69	3 170	45	64	3 516	83
S. aureus	68	3 230	23	66	3 354	21	69	3 475	14	70	3 614	20	66	3 881	35
S. pneumoniae	45	235	24	43	253	12	40	227	16	39	132	17	35	158	29
E. faecalis	65	1735	37	67	1944	35	66	1976	32	69	2 135	34	63	2 166	56
E. faecium	65	1585	34	65	1669	32	66	1829	27	68	2 204	31	65	2 567	63

Labs: laboratories.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Türkiye, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Türkiye, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	3652	77.7	4154	76.7	4290	78.8	3562	76.1	4365	74.8	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	4337	52.7	4923	53.2	4847	54.7	4342	53.4	4852	50.2	↓*
	Carbapenem (imipenem/meropenem) resistance	4321	2.7	4759	2.6	4966	3.0	4347	3.7	4551	4.7	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	4022	52.3	4606	52.2	4853	51.7	4193	50.1	4707	50.9	↓
	Aminoglycoside (gentamicin/tobramycin) resistance	4083	26.6	4785	24.4	4617	25.8	4211	23.7	4569	24.6	↓
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	3755	18.8	4477	17.7	4496	18.3	4078	16.5	4395	15.9	↓*
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	3157	72.0	3766	72.0	3977	74.0	4501	76.9	4738	75.4	↑*
	Carbapenem (imipenem/meropenem) resistance	3165	32.5	3641	34.4	4028	39.4	4517	48.2	4421	49.1	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	3009	61.1	3557	62.6	3933	64.8	4276	69.0	4483	68.6	↑*
	Aminoglycoside (gentamicin/tobramycin) resistance	2991	44.6	3632	45.9	3925	44.8	4405	46.6	4482	43.2	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	2821	38.9	3442	39.9	3689	40.5	4156	43.3	4203	38.7	–
P. aeruginosa	Piperacillin-tazobactam resistance	1491	37.2	1646	34.0	1533	34.1	1365	32.1	1764	32.5	↓
	Ceftazidime resistance	1481	30.0	1700	26.8	1645	28.0	1468	27.2	1723	28.1	–
	Carbapenem (imipenem/meropenem) resistance	1552	37.4	1682	37.5	1712	38.4	1547	36.2	1718	39.0	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1525	35.6	1674	32.7	1637	35.2	1503	31.0	1735	33.1	–
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	1519	26.7	1730	19.0	1681	20.8	769	15.7	1069	17.8	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	1279	31.7	1451	27.8	1424	30.1	672	27.5	955	28.1	–
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	2540	91.5	2643	92.2	2390	90.4	3165	93.1	3279	93.3	↑
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	2505	92.6	2575	94.4	2391	90.7	3064	93.6	3233	94.6	↑
	Aminoglycoside (gentamicin/tobramycin) resistance	2558	78.3	2704	79.1	2404	80.3	3117	86.1	3405	85.3	↑*
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	2421	77.8	2526	79.3	2362	79.6	3039	84.7	3089	84.8	↑*
S. aureus	MRSA[d]	3142	25.8	3316	29.6	3407	31.3	3591	33.4	3562	30.7	↑*
S. pneumoniae	Penicillin non-wild-type[e]	213	46.0	243	43.6	212	50.9	128	53.9	147	53.7	↑
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	205	39.5	217	37.3	211	37.0	119	34.5	126	34.1	–
	Combined penicillin non-wild-type and resistance to macrolides[e]	186	29.0	211	28.0	200	32.5	117	27.4	123	26.0	–
E. faecalis	High-level gentamicin resistance	1125	38.0	1337	36.9	1914	33.5	2040	29.6	1899	24.7	↓*
E. faecium	Vancomycin resistance	1551	13.2	1570	13.6	1797	13.3	2201	15.4	2242	15.8	↑

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).
[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.
[c] The aminoglycoside group includes only tobramycin from 2020 onwards.
[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.
[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

Turkmenistan

Participating institutions

State Sanitary-Epidemiological Services, Ministry of Health and Medical Industry

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Turkmenistan, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	ND	ND	11
Geographical representativeness	ND	ND	ND	ND	Low
Hospital representativeness	ND	ND	ND	ND	Low
Isolate representativeness	ND	ND	ND	ND	Low
Blood culture sets/1 000 patient days[a]	ND	ND	ND	ND	ND

ND: no data available.
Definitions provided on page 11.

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Turkmenistan, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	ND	ND	ND	ND	90
Percentage of laboratories participating in CAESAR EQA	ND	ND	ND	ND	NA

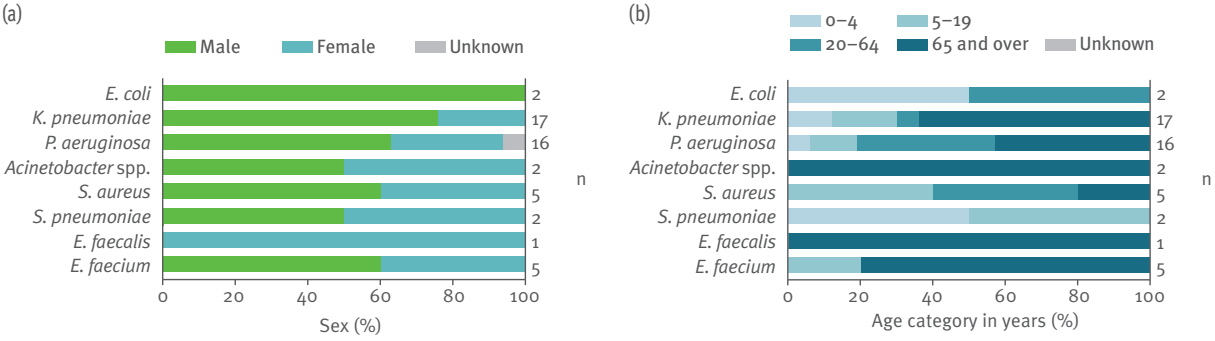
ND: no data available.
NA: not applicable.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Turkmenistan, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	2	NA
K. pneumoniae	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	17	NA
P. aeruginosa	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	16	NA
Acinetobacter spp.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	2	NA
S. aureus	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	5	NA
S. pneumoniae	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	2	NA
E. faecalis	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	1	NA
E. faecium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	5	NA

Labs: laboratories.
ND: no data available.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Turkmenistan, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Turkmenistan, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	ND	ND	ND	ND	ND	ND	ND	ND	15	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	14	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	17	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	17	NA	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	ND	ND	ND	ND	15	NA	NA
P. aeruginosa	Piperacillin-tazobactam resistance	ND	ND	ND	ND	ND	ND	ND	ND	14	NA	NA
	Ceftazidime resistance	ND	ND	ND	ND	ND	ND	ND	ND	15	NA	NA
	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	13	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	16	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	ND	ND	ND	ND	ND	ND	ND	ND	16	NA	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	ND	ND	ND	ND	ND	ND	ND	ND	12	NA	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	2	NA	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
S. aureus	MRSA[d]	ND	ND	ND	ND	ND	ND	ND	ND	4	NA	NA
S. pneumoniae	Penicillin non-wild-type[e]	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
E. faecalis	High-level gentamicin resistance	ND	ND	ND	ND	ND	ND	ND	ND	1	NA	NA
E. faecium	Vancomycin resistance	ND	ND	ND	ND	ND	ND	ND	ND	4	NA	NA

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

Ukraine

Participating institutions

Bacteriological Research Sector Reference Laboratory for the Diagnosis of Tuberculosis, Bacterial, Parasitic and Particularly Dangerous Pathogens, Public Health Center, Ministry of Health

Population and hospitals contributing data: coverage, representativeness and blood culture rate, Ukraine, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	0.5	1	2	10
Geographical representativeness	Medium	Medium	Medium	Medium	Medium
Hospital representativeness	Low	Low	Medium	Medium	High
Isolate representativeness	Low	Low	Low	Low	Low
Blood culture sets/1 000 patient days[a]	ND	9 (3–12)	3 (1–12)	3 (2–15)	5 (0–25)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, Ukraine, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	75	100	100	100	100
Percentage of laboratories participating in CAESAR EQA	100	100	100	100	NA

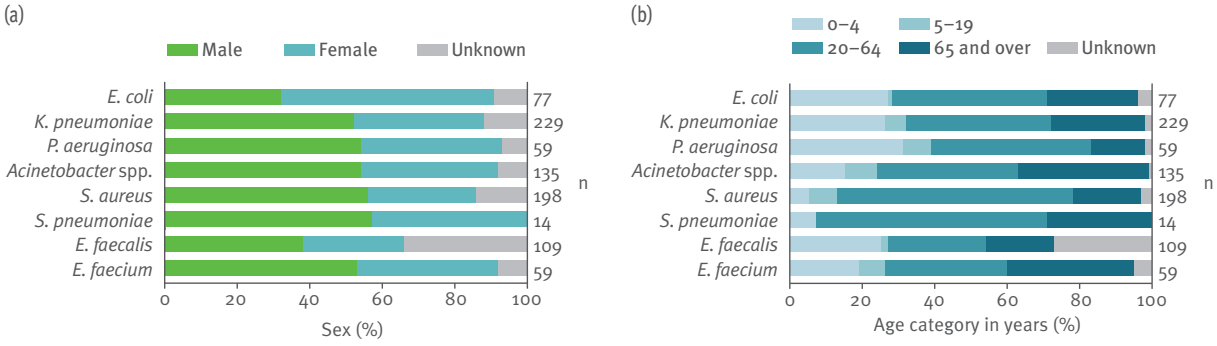
NA: not applicable.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, Ukraine, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	3	11	NA	4	18	NA	6	39	31	7	46	15	19	77	64
K. pneumoniae	4	30	50	4	38	50	6	75	58	10	102	NA	24	229	69
P. aeruginosa	2	9	NA	3	10	NA	5	16	NA	6	28	50[c]	15	59	62
Acinetobacter spp.	4	32	32	4	29	48[c]	7	44	65	9	52	56	20	135	76
S. aureus	4	20	20[c]	4	22	41[c]	7	68	40	11	91	10	26	198	37
S. pneumoniae	2	6	NA	1	1	NA	3	8	NA	2	9	NA	7	14	NA
E. faecalis	4	31	23	4	29	21[c]	7	46	33	10	54	30	18	109	65
E. faecium	2	12	NA	2	8	NA	4	12	NA	7	23	NA	13	59	76

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).
[c] A small number of isolates were tested (n < 30), and the percentage of isolates from ICUs should be interpreted with caution. See Annex 3 for more information.

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, Ukraine, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, Ukraine, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	11	NA	12	NA	17	NA	21	71.4[f]	56	57.1	NA
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	11	NA	18	NA	39	41.0	45	53.3	77	57.1	NA
	Carbapenem (imipenem/meropenem) resistance	11	NA	18	NA	31	6.5	45	4.4	77	10.4	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	11	NA	18	NA	37	35.1	43	41.9	76	43.4	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	10	NA	18	NA	35	20.0	42	35.7	74	24.3	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	10	NA	18	NA	34	11.8	40	17.5	73	12.3	NA
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	30	56.7	37	83.8	72	91.7	96	84.4	228	89.9	NA
	Carbapenem (imipenem/meropenem) resistance	29	27.6[f]	37	43.2	67	61.2	100	53.0	225	64.4	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	29	69.0[f]	38	78.9	71	83.1	96	79.2	227	83.7	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	25	56.0[f]	35	65.7	69	76.8	83	61.4	217	79.7	NA
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	25	40.0[f]	34	58.8	68	70.6	79	58.2	215	75.3	NA
P. aeruginosa	Piperacillin-tazobactam resistance	7	NA	9	NA	12	NA	24	54.2[f]	53	75.5	NA
	Ceftazidime resistance	8	NA	10	NA	15	NA	27	59.3[f]	59	81.4	NA
	Carbapenem (imipenem/meropenem) resistance	9	NA	10	NA	16	NA	27	70.4[f]	59	78.0	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	8	NA	9	NA	15	NA	26	57.7[f]	59	81.4	NA
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	7	NA	9	NA	15	NA	25	56.0[f]	56	82.1	NA
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	7	NA	9	NA	12	NA	22	54.5[f]	53	81.1	NA
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	30	40.0	28	75.0[f]	44	72.7	52	76.9	135	73.3	NA
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	25	80.0[f]	29	86.2[f]	41	90.2	51	88.2	135	77.8	NA
	Aminoglycoside (gentamicin/tobramycin) resistance	18	NA	27	81.5[f]	40	85.0	47	70.2	135	60.0	NA
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	18	NA	26	65.4[f]	38	76.3	46	58.7	135	51.1	NA
S. aureus	MRSA[d]	19	NA	20	0.0[f]	60	1.7	86	18.6	176	30.1	NA
S. pneumoniae	Penicillin non-wild-type[e]	6	NA	1	NA	8	NA	9	NA	13	NA	NA
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	6	NA	1	NA	8	NA	9	NA	14	NA	NA
	Combined penicillin non-wild-type and resistance to macrolides[e]	6	NA	1	NA	8	NA	9	NA	13	NA	NA
E. faecalis	High-level gentamicin resistance	18	NA	19	NA	29	51.7[f]	36	41.7	64	34.4	NA
E. faecium	Vancomycin resistance	12	NA	8	NA	12	NA	19	NA	59	6.8	NA

NA: not applicable.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

[f] A small number of isolates were tested (n < 30), and the percentage resistance should be interpreted with caution. See Annex 3 for more information.

United Kingdom

Data for the United Kingdom includes England, Scotland and Northern Ireland

Participating institutions

UK Health Security Agency (UKHSA)
Health Protection Scotland
Public Health Agency Northern Ireland

Population and hospitals contributing data: coverage, representativeness and blood culture rate, United Kingdom, 2017–2021

Parameter	2017	2018	2019	2020	2021
Estimated national population coverage (%)	ND	ND	ND	ND	32
Geographical representativeness	ND	Medium	Medium	Medium	Medium
Hospital representativeness	ND	High	High	High	High
Isolate representativeness	ND	High	High	High	High
Blood culture sets/1 000 patient days[a]	ND	ND	ND	ND	51 (0–187)

ND: no data available.
Definitions provided on page 11.
[a] Data are presented as mean (range).

Laboratories contributing data: use of clinical breakpoint guidelines and participation in CAESAR EQA, United Kingdom, 2017–2021

Parameter	2017	2018	2019	2020	2021
Percentage of laboratories using EUCAST or EUCAST-harmonised guidelines	96	100	100	100	100
Percentage of laboratories participating in CAESAR EQA	82	82	84	NA	6

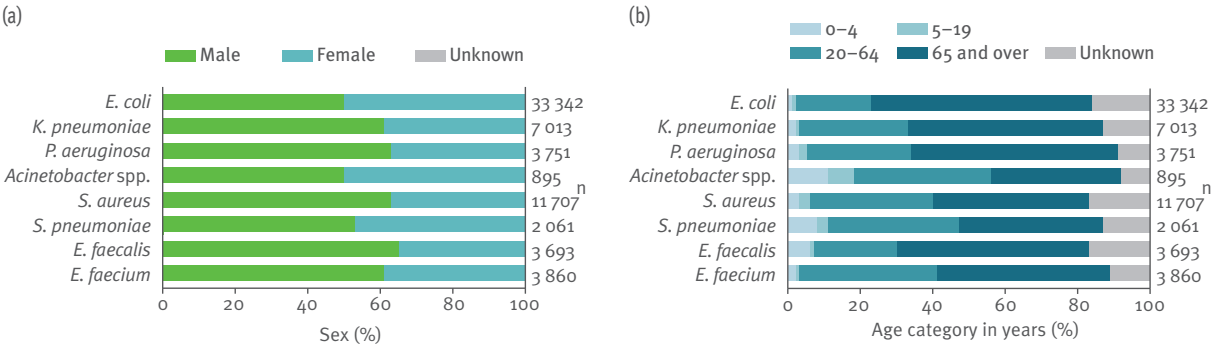
NA: not applicable.

Annual number of reporting laboratories,[a] number of reported isolates and percentage[b] of isolates reported from patients in ICUs, United Kingdom, 2017–2021

Bacterial species	2017			2018			2019			2020			2021		
	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)	Labs (n)	Isolates (n)	Isolates from ICU (%)
E. coli	94	28599	NA	93	29534	NA	91	30225	NA	91	25018	NA	121	33342	NA
K. pneumoniae	93	5040	NA	92	5302	NA	91	5428	NA	90	4760	NA	118	7013	NA
P. aeruginosa	92	2673	NA	88	2575	NA	89	2764	NA	88	2382	NA	117	3751	NA
Acinetobacter spp.	86	740	NA	79	682	NA	83	743	NA	84	594	NA	107	895	NA
S. aureus	94	9003	NA	91	8559	NA	91	9462	NA	91	8367	NA	120	11707	NA
S. pneumoniae	90	3887	NA	87	4065	NA	89	4009	NA	86	1610	NA	117	2061	NA
E. faecalis	91	2529	NA	90	2608	NA	86	2681	NA	85	2500	NA	116	3693	NA
E. faecium	89	2112	NA	86	2488	NA	88	2473	NA	86	2454	NA	116	3860	NA

Labs: laboratories.
NA: not applicable.
[a] Number of laboratories reporting at least one isolate during the specific year. The total number of participating laboratories might be higher.
[b] Isolates with missing information on hospital department are excluded from the calculation, and the percentage of isolates from ICU is presented only if there are ≥20 isolates of which ≥ 70% have data on hospital department. If not, the percentage is presented as not applicable (NA).

Percentage of isolates by patient sex (a) and age group (b), by bacterial species, United Kingdom, 2021



Total number of invasive isolates tested (n) and percentage of isolates with resistance phenotype (%)[a], by bacterial species and antimicrobial group/agent, United Kingdom, 2017–2021

Bacterial species	Antimicrobial group/agent	2017		2018		2019		2020		2021		Trend 2017–2021[b]
		n	%	n	%	n	%	n	%	n	%	
E. coli	Aminopenicillin (amoxicillin/ampicillin) resistance	25165	62.1	25838	60.3	27263	60.2	23404	58.4	31207	56.9	↓*
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	24854	9.9	25377	10.7	25711	11.5	21814	10.5	29613	11.1	↑
	Carbapenem (imipenem/meropenem) resistance	26508	0.0	27491	0.0	28605	0.0	24043	0.1	31807	0.0	–
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	26619	17.3	27613	17.7	28726	17.8	24260	16.4	32296	16.3	↓*
	Aminoglycoside (gentamicin/tobramycin) resistance	27279	9.9	28425	10.5	29458	10.7	24593	9.9	32709	10.1	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	23171	4.0	23858	4.4	24791	4.7	21320	3.9	28842	4.3	–
K. pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	4431	11.1	4598	12.4	4673	12.7	4165	12.9	6254	13.8	↑*
	Carbapenem (imipenem/meropenem) resistance	4641	0.7	4901	0.7	5050	0.6	4562	0.3	6527	0.0	↓*
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	4673	8.8	4927	12.6	5086	12.3	4587	12.2	6713	13.3	↑*
	Aminoglycoside (gentamicin/tobramycin) resistance	4775	8.0	5047	8.8	5183	7.9	4653	7.8	6828	9.1	–
	Combined resistance to third-generation cephalosporins, fluoroquinolones and aminoglycosides	4096	4.1	4270	5.1	4426	4.9	4060	5.1	6046	5.7	↑*
P. aeruginosa	Piperacillin-tazobactam resistance	2377	5.2	2252	5.3	2473	5.6	2249	6.5	3474	6.6	↑*
	Ceftazidime resistance	2368	4.6	2309	5.0	2531	5.2	2251	5.4	3571	5.7	–
	Carbapenem (imipenem/meropenem) resistance	2481	5.2	2419	6.1	2638	6.0	2308	6.4	3632	7.5	↑*
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	2476	8.0	2420	10.0	2656	8.6	2332	9.0	3660	8.2	–
	Aminoglycoside (gentamicin/tobramycin) resistance[c]	2536	3.7	2471	4.4	2692	4.2	1370	1.5	2204	1.7	↓*
	Combined resistance to ≥ 3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones and aminoglycosides)[c]	2042	2.6	1962	2.8	2234	3.2	1302	3.9	2019	4.9	↑*
Acinetobacter spp.	Carbapenem (imipenem/meropenem) resistance	688	2.6	635	1.9	715	2.1	572	1.7	865	2.1	–
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	702	6.1	647	2.9	704	7.1	550	7.8	853	6.2	–
	Aminoglycoside (gentamicin/tobramycin) resistance	704	4.4	655	5.5	716	5.2	573	2.4	843	3.7	–
	Combined resistance to carbapenems, fluoroquinolones and aminoglycosides	645	1.4	590	1.0	665	1.2	526	0.4	796	1.0	–
S. aureus	MRSA[d]	7562	6.3	7651	7.1	8767	5.9	7397	5.1	4365	5.6	↓*
S. pneumoniae	Penicillin non-wild-type[e]	3452	5.7	3607	6.1	3523	5.7	1470	7.5	1837	6.9	↑
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	3772	5.8	3914	5.7	3734	5.5	1513	6.1	1984	6.9	–
	Combined penicillin non-wild-type and resistance to macrolides[e]	3362	2.1	3476	2.2	3276	2.4	1379	2.8	1769	2.3	–
E. faecalis	High-level gentamicin resistance	ND	ND	ND	ND	19	NA	160	22.5	220	20.5	NA
E. faecium	Vancomycin resistance	1956	25.1	2294	24.6	2348	22.2	2393	21.9	3704	23.1	↓*

NA: not applicable.
ND: no data available.

[a] Percentages of isolates with resistance phenotype are presented only if data are available for ≥20 isolates. If not, the percentage is presented as not applicable (NA).

[b] ↑ and ↓ indicate statistically significant increasing and decreasing trends, respectively, in the overall data; * indicates confirmation in the form of a significant trend in the data that only included laboratories reporting continuously for all five years; - indicates no statistically significant trend. NA: not applicable indicates that the data were not reported for all years, a significant change in data source occurred during the period, or the number of isolates was < 20 in any year during the period.

[c] The aminoglycoside group includes only tobramycin from 2020 onwards.

[d] MRSA is based on cefoxitin, or, if unavailable, oxacillin. If neither were available, data from molecular confirmation tests (detection of *mecA* gene by PCR or a positive PBP2A-agglutination test) are accepted as a marker for MRSA.

[e] Penicillin results are based on penicillin or, if unavailable, oxacillin. For *S. pneumoniae*, the term penicillin non-wild-type is used in this report, referring to *S. pneumoniae* isolates reported by the local laboratories as susceptible increased exposure (I) or resistant (R) to penicillin, assuming MIC to benzylpenicillin above those of wild-type isolates (> 0.06 mg/L). The qualitative susceptibility categories (S/I/R) as reported by the laboratory are used, since quantitative susceptibility information is missing for a large part of the data. Laboratories not using EUCAST clinical breakpoints may have used different interpretive criteria for susceptibility categories.

Recommended reading

European Centre for Disease Prevention and Control (ECDC). EARS-NET reporting protocol 2022. Stockholm: ECDC; 2022. Available at: https://www.ecdc.europa.eu/en/publications-data/ears-net-reporting-protocol-2022

European Centre for Disease Prevention and Control (ECDC). Surveillance Atlas of Infectious Diseases. In: ECDC [website]. Stockholm: ECDC; 2022. Available at: https://www.ecdc.europa.eu/en/surveillance-atlas-infectious-diseases

WHO Regional Office for Europe (WHO/Europe)/European Centre for Disease Prevention and Control (ECDC). Antimicrobial resistance surveillance in Europe 2022 – 2020 data. Copenhagen: WHO/Europe; 2022. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/ECDC-WHO-AMR-report.pdf

5. Annexes

Annex 1. Participating institutions

Country	Participating institutions	Web link
EU/EEA		
Austria	Federal Ministry of Health and Women's Affairs	www.bmgf.gv.at
	Medical University Vienna	www.meduniwien.ac.at
	Ordensklinikum Linz, Elisabethinen	www.ordensklinikum.at
Belgium	Sciensano	www.sciensano.be
Bulgaria	National Center of Infectious and Parasitic Diseases	https://ncipd.org/index.php?option=com_content&view=featured&Itemid=730&lang=en
Croatia	Reference Center for Antimicrobial Resistance Surveillance	https://bfm.hr/referentni-centar-za-pracenje-rezistencije-bakterija-na-antibotike/
	Ministry of Health Zagreb University Hospital for Infectious Diseases "Dr Fran Mihaljević"	https://bfm.hr/
Cyprus	Microbiology Department, Nicosia General Hospital	https://shso.org.cy/clinic/mikroviologiko/
Czechia	National Institute of Public Health	www.szu.cz
	National Reference Laboratory for Antibiotics	http://www.szu.cz/national-reference-laboratory-for-antibiotics
Denmark	Statens Serum Institut	https://www.ssi.dk/
	Danish Study Group for Antimicrobial Resistance Surveillance (DANRES)	www.danmap.org
Estonia	Estonian Health Board	https://www.terviseamet.ee/et
	East-Tallinn Central Hospital	https://itk.ee/
	Tartu University Hospital	https://www.kliinikum.ee/partnerile/uhendlabor/
Finland	Finnish Institute for Health and Welfare, Department of Health Security	www.thl.fi
	Finnish Study Group for Antimicrobial Resistance (FiRe)	www.finres.fi
	Finnish Hospital Infection Program (SIRO)	thl.fi/en/web/infectious-diseases/surveillance/healthcare-associated-infections
France	Santé Publique France	www.santepubliquefrance.fr
	Since 2020:	
	Surveillance and Prevention of Antimicrobial RESistance in hospital settings (SPARES)	https://www.preventioninfection.fr/
	National Reference Centre for Pneumococci	www.cnr-pneumo.com
	Up to 2019:	
	French National Observatory for the Epidemiology of Bacterial Resistance to Antimicrobials (ONERBA) through three participating networks: Azay-Résistance; Île-de-France; Réussir	www.onerba.org
Germany	Robert Koch Institute	www.rki.de
Greece	National Public Health Organization, Central Public Health Laboratory	
	University of West Attica, Department of Public Health Policy, School of Public Health	
Hungary	National Public Health Center	www.oek.hu
Iceland	National University Hospital of Iceland	https://www.landspitali.is
	Centre for Health Security and Infectious Disease Control	https://www.landlaeknir.is
	Akureyri Hospital	www.sak.is
Ireland	Health Protection Surveillance Centre	www.hpsc.ie
Italy	National Institute of Health	www.iss.it
Latvia	Disease Prevention and Control Center of Latvia	www.spkc.gov.lv
Liechtenstein	–	
Lithuania	National Public Health Surveillance Laboratory	www.nvspl.lt
	Institute of Hygiene	www.hi.lt
Luxembourg	National Health Laboratory	https://lns.lu/
	Microbiology Laboratory, Centre Hospitalier de Luxembourg	https://www.chl.lu/fr/service/laboratoire-de-bacteriologie-microbiologie
Malta	Malta Mater Dei Hospital, Msida	
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, Department of Epidemiology and Clinical Microbiology	https://www.nil.gov.pl
	National Reference Centre for Susceptibility Testing	https://korld.nil.gov.pl
Portugal	National Institute of Health Doutor Ricardo Jorge	www.insarj.pt
	Ministry of Health Directorate-General of Health	
	Directorate-General of Health	
Romania	National Institute of Public Health	www.insp.gov.ro

Country	Participating institutions	Web link
Slovakia	National Reference Centre for Antimicrobial Resistance	
	Public Health Authority of the Slovak Republic	https://www.uvzsr.sk
	Regional Public Health Authority Banska Bystrica	
Slovenia	National Institute of Public Health	www.nijz.si
	Medical Faculty, University of Ljubljana	https://imi.si/
	National Laboratory of Health, Environment and Food	https://www.nlzoh.si/
Spain	Health Institute Carlos lll	https://www.isciii.es
	National Centre for Microbiology	
Sweden	The Public Health Agency of Sweden	www.folkhalsomyndigheten.se
WHO European Region (excluding EU/EEA)		
Albania	Institute of Public Health	https://www.ishp.gov.al/
Armenia	Public Health Department, Ministry of Health	https://www.moh.am/?section=main/index&id=116#1/1028
Azerbaijan	Sector of Sanitary Epidemiological Surveillance, Ministry of Health	https://sehiyye.gov.az/
Belarus	Laboratory for Clinical and Experimental Microbiology, Republican Research and Practical Center for Epidemiology and Microbiology	https://www.belriem.by/en/
Bosnia and Herzegovina	Clinical Microbiology Department, Clinical Center University of Sarajevo	https://www.kcus.ba/
	Department of Microbiology, Department of Clinical Microbiology/University Clinical Centre of Republika Srpska	https://www.kc-bl.com/En/?page_id=1989
Georgia	National Center for Disease Control and Public Health	https://www.ncdc.ge/#/home
Kazakhstan	National Center on Public Health Development, Ministry of Health	https://www.gov.kz/memleket/entities/dsm?lang=en
Kosovo[1]	Department of Medical Microbiology, Institute of Public Health of Kosovo[1]	http://niph-rks.org/
Kyrgyzstan	Public Health Department, Ministry of Health	
Moldova	National Agency for Public Health, Ministry of Health	https://ms.gov.md/en/
Montenegro	Department of Bacteriology, Institute of Public Health	https://www.ijzcg.me/
North Macedonia	Laboratory for Bacteriology, Department of Microbiology, Institute of Public Health	https://www.iph.mk/en/laboratory/microbiology/
Russia	Institute of Antimicrobial Chemotherapy, Smolensk State Medical Academy	https://www.antibiotic.ru/
Serbia	Department of Clinical Microbiology with the Reference Laboratory for Bacterial Resistance to Antimicrobials, Centre for Microbiology, Institute of Public Health of Vojvodina, Novi Sad	http://izjzv.org.rs/?lng=eng&link=10-38
Switzerland	Swiss Centre for Antibiotic Resistance, Institute for Infectious Diseases, University of Bern	https://www.anresis.ch/
Tajikistan	State Sanitary Epidemiology Surveillance Service, Ministry of Health and Social Protection of the Population	https://moh.tj/en/
Türkiye	Department of Microbiology Reference Laboratories and Biological Products, General Directorate of Public Health, Ministry of Health	https://hsgm.saglik.gov.tr/tr/mikrobiyoloji-anasayfa
Turkmenistan	Department of Acute Dangerous Disease Surveillance, State Sanitary Epidemiology Service, Ministry of Health and Medical Industry	
Ukraine	Reference Laboratory for Microbiological and Parasitological Research, Public Health Center, Ministry of Health	https://phc.org.ua/
United Kingdom	UK Health Security Agency	https://www.gov.uk/government/organisations/uk-health-security-agency
	Public Health Agency Northern Ireland	https://www.publichealth.hscni.net/
	Health Protection Scotland	https://www.hps.scot.nhs.uk/
Uzbekistan	AMR Reference Center, Research Institute of Epidemiology, Microbiology and Infectious Diseases	https://uzinfectology.uz/

[1] This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the International Court of Justice Opinion on the Kosovo Declaration of Independence.

Annex 2. Tripartite Antimicrobial resistance Country Self-assessment Survey (TrACSS) 2022

Multisector and One Health collaboration/coordination (Indicator 2 in Table 6)
A. No formal multisectoral governance or coordination mechanism on antimicrobial resistance (AMR) exists.
B. Multisectoral coordination mechanism on AMR established with Government leadership.
C. Formalised multisector coordination mechanism with technical working groups established with clear terms of reference, regular meetings, and funding for working group(s) with activities and reporting/accountability arrangements defined.
D. Joint working on issues including agreement on common objectives.
E. Integrated approaches used to implement the national AMR action plan with relevant data and lessons learned from all sectors used to adapt implementation of the action plan.
Country progress with development of a national action plan on AMR (Indicator 3 in Table 6)
A. No national AMR action plan under development.
B. National AMR action plan developed.
C. National AMR action plan approved by government and is being implemented.
D. National AMR action plan has costed and budgeted operational plan and has monitoring mechanism in place.
E. Financial provision for the National AMR action plan implementation is included in the national plans and budgets.
National surveillance system for AMR in humans (Indicator 4 in Table 6)
A. No capacity for generating data (antibiotic susceptibility testing and accompanying clinical and epidemiological data) and reporting on antibiotic resistance.
B. AMR data is collated locally for common bacterial infections in hospitalised and community patients, but data collection may not use a standardised approach and lacks national coordination and/or quality management.
C. AMR data are collated nationally for common bacterial infections in hospitalised and community patients, but national coordination and standardisation are lacking.
D. There is a standardised national AMR surveillance system collecting data on common bacterial infections in hospitalised and community patients, with established network of surveillance sites, designated national reference laboratory for AMR, and a national coordinating centre producing reports on AMR.
E. The national AMR surveillance system links AMR surveillance with antimicrobial consumption and/or use data for human health.
Infection prevention and control (IPC) in human healthcare (Indicator 8 in Table 6)
A. No national IPC programme or operational plan is available.
B. A national IPC programme or operational plan is available. National IPC and water, sanitation and hygiene (WASH) and environmental health standards exist but are not fully implemented.
C. A national IPC programme and operational plan are available and national guidelines for healthcare IPC are available and disseminated. Selected health facilities are implementing the guidelines, with monitoring and feedback in place.
D. National IPC programme available according to the WHO IPC core components guidelines and IPC plans and guidelines implemented nationwide. All healthcare facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.
E. IPC programmes are in place and functioning at national and health facility levels according to the WHO IPC core components guidelines. Compliance and effectiveness are regularly evaluated and published. Plans and guidance are updated in response to monitoring.
Optimising antimicrobial use in human health (Indicator 9 in Table 6)
A. No/weak national policies for appropriate antimicrobial use including availability, quality, and disposal of antimicrobials.
B. National policies promoting appropriate antimicrobial use/antimicrobial stewardship activities developed for the community and healthcare settings.
C. National guidelines for appropriate use of antimicrobials are available and antimicrobial stewardship programs are being implemented in some healthcare facilities.
D. National guidelines for appropriate use of antimicrobials are available and antimicrobial stewardship programs are being implemented in most healthcare facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.
E. National guidelines on optimising antibiotic use are implemented for all major syndromes and data on use is systematically fed back to prescribers.

Source: WHO *(1)*.

Reference

1. World Health Organization (WHO). Tripartite AMR country self-assessment survey – TrACSS (6.0) 2022. Geneva: WHO; 2022. Available at: https://www.who.int/publications/m/item/tripartite-amr-country-self-assessment-survey---tracss-(6.0)-2022 , accessed 25 10 2022.

Annex 3. Data quality and interpretation

The results presented in this report – regional results, inter-country comparisons and, in some cases, national trends – should be interpreted with caution. Several factors may influence the estimates and may result in over- as well as under-estimation of antimicrobial resistance (AMR) percentages.

Random versus systematic error

Every measurement includes a risk of deviation from the true value due to either random or systematic error. Random error, also known as natural variation or chance variation, may not be error in the strict sense, but arises from unpredictable factors influencing the measurement. As a consequence, results will differ across measurements, even when measurement conditions are the same. Some measurement outcomes will be higher than the true value, others will be lower than the true value. On the other hand, systematic error is consistent, repeated error associated with the study design or data analysis, or with flawed measurement equipment. Systematic error consistently under- or over-estimates the true value in the same direction for all measurements.

When combining results from multiple measurements, deviations due to random error (under- and over-estimations occurring in single measurements) cancel out and the average is a good estimation of the true average, assuming no systematic error and provided that the number of measurements is sufficiently large (see section on 'Sampling variation' below). However, as systematic error leads to either under- or over-estimation of the true value for all measurements, the average will also be under- or over-estimated. This deviation from the true average is called bias. The overall degree of bias in the data collected is the net result of different sources of systematic error that can each lead to deviation from the true average in a different direction (under- or over-estimation) and to a different extent.

Random error will occur with every measurement, and investigators can only reduce the amount of error to a certain extent. Systematic error, on the other hand, can be significantly reduced by careful consideration of certain aspects of the data-generation process. When systematic error cannot be avoided, it is important (if possible) to evaluate the resulting bias, its extent and direction. Common sources of error and bias in AMR surveillance data are described in detail below and summarised in Table A3.1.

Random error

Sampling variation

The aim of the European Antimicrobial Resistance Surveillance Network (EARS-Net) and the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network is to provide an overview of average AMR percentages in invasive isolates for a particular country. The population of interest (target population) is all patients with those infections. However, for practical reasons it often is not possible to include data from blood or cerebrospinal fluid (CSF) samples for all these patients and therefore data may be collected from a selection (sample) instead. Each patient from whom a blood or CSF sample is taken, and each bacterial strain isolated from them, is different. When all the measurements for these patients are combined, the average reflects the group of patients who were sampled. When the group is small, the average may not reflect the true average for the target population because it is possible that, by chance, a lower or higher proportion of patients with resistant infections are sampled than the distribution in the target population. Fig. A3.1 shows that the larger the sample size, the closer the average in the sample will be to the average in the target group. Finding (by chance) only one more or one less resistant isolate in a sample affects the average found in smaller samples much more than the average for larger samples. In other words, AMR percentages based on small sample sizes are, to a larger extent, affected by random sampling variation and potential outbreaks of resistant pathogens, whereas percentages based on large sample sizes are more likely to approximate the true average (provided there is no systematic error).

Measurement variation

Random error also arises from slight variations in how measurement procedures are applied across measurements. For example, the concentration of an inoculum that is plated out when testing antimicrobial susceptibility using disk diffusion will vary each time. Random variation in the concentration of the inoculum will result in larger inhibition zones for some samples and smaller zones for others. Depending on the specific breakpoints applied to these zones, this may lead to variation in categorising isolates as susceptible, standard dosing regimen (S), susceptible, increased exposure (I) or resistant (R). Random measurement variation will be a combination of variation in both directions, and the larger the sample, the more likely it is that these will cancel out when results are combined. In antimicrobial susceptibility testing (AST), the variation depends on the skills of laboratory technicians and the variation that arises from measurements taken by different technicians. Standardising procedures, training laboratory staff and ensuring quality are essential to minimise random measurement variation.

Systematic error

Bias related to sampling

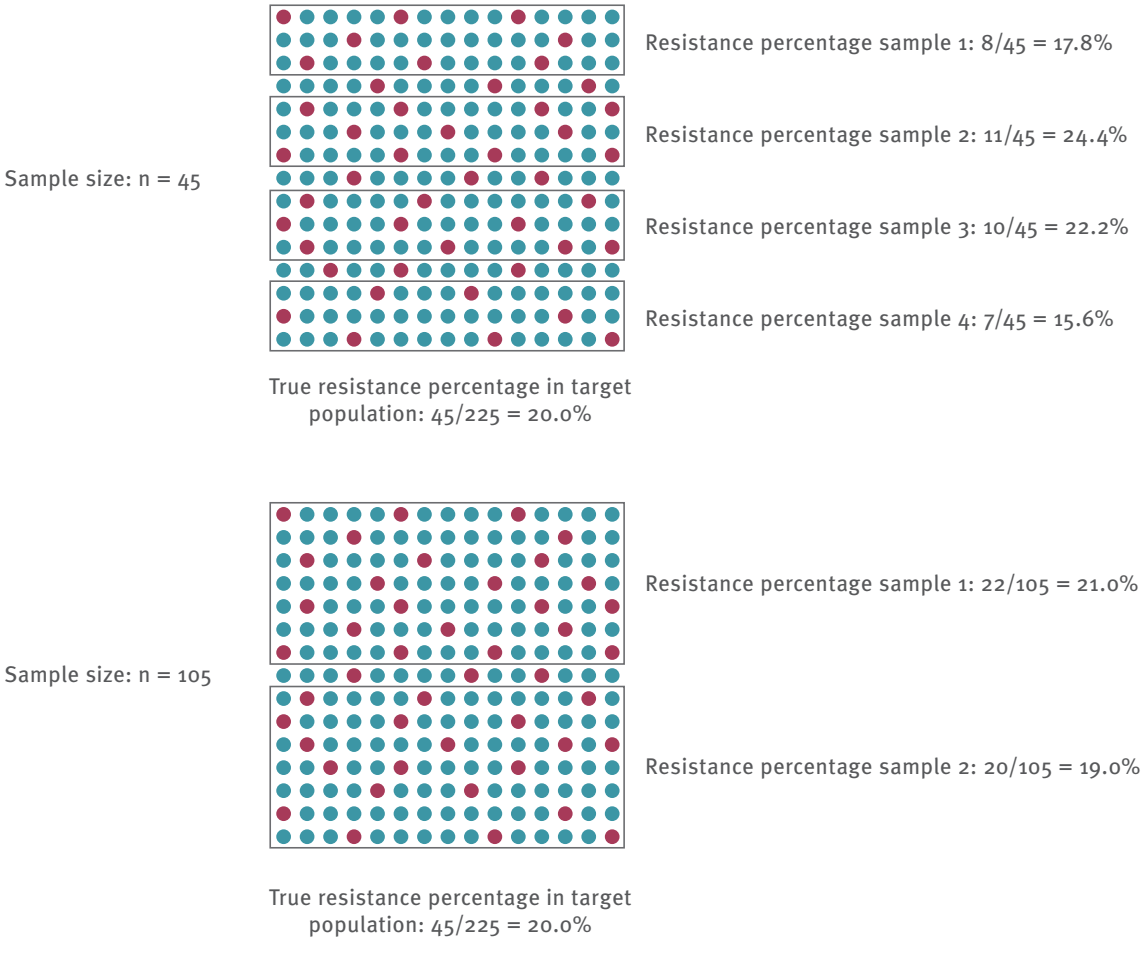
Participating sites

Ideally, all medical microbiology laboratories should be included to obtain a representative assessment of AMR in a country. As this may not be feasible in practice, the selection of participating laboratories in the surveillance system should be representative of all laboratories. Laboratories from different geographical and climatic regions of the country, rural and urban areas and laboratories processing samples from different patient populations (hospital types and departments) should therefore be included. For reasons of convenience, it is often only the more advanced laboratories, which are most likely to be located in urban areas and providing services for specialised or tertiary-care facilities, that are included. Consequently, the data will reflect an under-representation of patients treated in general hospitals in rural areas, in whom AMR is generally lower than in patients whose samples are tested by more advanced laboratories. The results will therefore be biased towards higher percentages and will not necessarily be generalisable to the overall patient population.

Patients

When surveillance is based on routine diagnostic testing (passive surveillance), as in this report, data should be interpreted with extra caution. The data used in this type of surveillance are not generated with surveillance as the primary objective, but as part of routine patient care. The data therefore reflect only patients who were judged by clinicians to be eligible for bacteriology diagnostics, taking clinical predictions into consideration. Often, samples are predominantly taken from severely ill patients, patients with recurrent infections for whom treatment is problematic or patients strongly suspected of having resistant infections. Healthy patients with uncomplicated infections are less likely to have a sample taken. The data will therefore reflect an under-representation of patients with uncomplicated infections – in whom AMR generally is lower than in patients with complicated infections – and AMR results will be biased towards higher percentages. In active surveillance, by contrast, clear case definitions are generally used to identify patients who need to be sampled – to reduce

Fig. A3.1 AMR percentages obtained in various small and larger samples from a target population with a true AMR percentage of 20%



the influence of clinical judgement or other factors leading to selective patient sampling – and specific efforts are made to attain a representative sample of the target population.

Obtaining results that are representative of the target population requires ensuring that all patients fitting the case definition are sampled. In the case of EARS-Net and CAESAR, all patients presenting with signs of a bloodstream infection, sepsis or meningitis should be sampled. If only specific patient categories are sampled (such as patients in intensive care units (ICU) or tertiary-care institutions, or patients with chronic or recurring infection, relapses or treatment failure), the AMR percentage will be over-estimated, as these patients will have been subjected to selective pressure of antimicrobial agents and will therefore be more likely to be infected with a resistant microorganism.

The use of microbiological diagnostics depends on financial and logistic possibilities outside the control of a surveillance system. For example, not every eligible patient may be sampled in routine clinical care if bacteriology diagnostics are not reimbursed through health insurance, laboratory capacity is limited, or results are not communicated in a sufficiently timely manner to influence clinical decision-making. Patients may have samples taken after antimicrobial therapy has already started or following self-treatment in settings where over-the-counter sale of antibiotics is common. This results in an under-representation of infections that respond to first-line antibiotics with consequent over-estimation of AMR percentages.

Timing

The timing of sample collection may also influence the AMR percentages found. Ad hoc or convenience sampling for a limited period, especially during outbreaks, will bias results. This can to some extent be overcome by sampling throughout the year.

Bias related to laboratory procedures

Measurement error

Measurement values vary whenever measurements are taken. In addition to random variation, systematic error in measurements may occur. For example, when the agar depth of plates used for disk diffusion is consistently too small, inhibition zones will be over-estimated for all isolates. Depending on the specific breakpoints applied to these zones, this may lead to isolates being categorised S when they should be I, or I when they should be R. Since the error is made in the same direction for all isolates, they do not cancel out and AMR will be under-estimated when combining the results. Systematic measurement error occurs when laboratory procedures are not followed, when poor-quality laboratory materials are used (such as old growth media or expired antimicrobial disks) or when automated systems are damaged, or not properly calibrated. Systematic error can also occur in species identification. Correctly identifying species is important for interpreting the percentages of AMR. Some species are more clinically relevant than others, and their capacity to acquire AMR or their intrinsic AMR varies. Sometimes the data clearly suggest problems with species identification. For example, a high percentage of ampicillin resistance in *Enterococcus faecalis* may be the result of *Enterococcus faecium* being misclassified as *Enterococcus faecalis*.

A laboratory quality-management system and regular application of internal quality-assurance procedures facilitates the timely detection and correction of systematic error in laboratory procedures. Auditing and accreditation schemes in conjunction with external quality assessment (EQA) programmes ensure that laboratories adhere to national quality standards.

It should be noted that specific highly resistant microorganisms or exceptional antimicrobial-resistant phenotypes (such as carbapenem-resistant Enterobacterales) may need confirmation by additional testing to assess whether the findings are correct or a result of laboratory error. This double-checking of results is important because finding these types of organisms may have considerable consequences for empirical antimicrobial therapy and for IPC policies.

AST procedures and interpretation

To ensure accurate results, AST should be performed according to scientifically-validated guidelines. Both the European Committee on Antimicrobial Susceptibility Testing (EUCAST) and the Clinical and Laboratory Standards Institute provide comprehensive methodological guidelines for routine AST, confirmatory testing and interpretation of results. Laboratory methods and interpretive criteria (clinical breakpoints) may differ, depending on the guidelines and change over time. For example, a *Klebsiella pneumoniae* isolate with an inhibition zone of 16 mm for imipenem is considered I when EUCAST breakpoints 2018 are applied, but R with EUCAST 2019 breakpoints. AST results may therefore be incomparable across laboratories using different (versions of) guidelines, and time trends in the AMR percentage may be affected by, or occur as a result of changes in breakpoints used by laboratories over time.

In practice, when interpreting AST results in the context of routine patient care, expert rules are often used in addition to clinical breakpoints. For example, if *Staphylococcus aureus* is resistant to cefoxitin, it is reported as resistant to all beta-lactam antimicrobial agents, with the possible exception of ceftaroline and/or ceftobiprole. Expert rules are provided by EUCAST, but laboratories or surveillance systems may also use different expert rules, which complicates the comparison of data obtained in different laboratories or countries.

It is important that susceptibility to all indicated antimicrobial agents is tested for each isolate included in surveillance. Differential or sequential testing, such as testing carbapenems only when resistance to third-generation cephalosporins is found or only for patients

suspected of a resistant infection, will lead to under-representation of isolates susceptible to carbapenems and over-estimation of the resistance percentage.

Bias related to data-analysis procedures

Patients are often sampled repeatedly during their infection episode for diagnostic purposes or to assess therapeutic response. Follow-up samples more often are required in patients with infections caused by resistant microorganisms than those with infections due to susceptible microorganisms, since the latter are more likely to be treated successfully with antimicrobial therapy. If all follow-up isolates from the same patient are included when calculating the proportion of AMR, resistant isolates will be overrepresented, leading to overestimation of the AMR percentage. To prevent this, EARS-Net and CAESAR include only the first isolate per bacterial species per person per year in analyses.

Data interpretation and generalisability

When interpreting AMR surveillance data, it is important to evaluate the extent to which the results obtained in the sample are likely to be a good estimate of the average AMR percentage in the target population. Unless all patients can be sampled the true AMR percentage in the target population is always unknown, but assumptions can be made according to the representativeness of the sample. Whether they involve the selection of participating sites or of patients eligible for bacteriology diagnostics in routine clinical care, the issues related to sampling mentioned in the section 'Bias related to sampling' above may lead to a sample of specific patients in which the average AMR percentage deviates from that in the target population – a biased estimate of the AMR percentage in which EARS-Net and CAESAR are interested. It is therefore important to realise that results obtained in a population of ICU patients in tertiary-care facilities, for instance, can and should be interpreted as applicable to this specific patient population, but may not be generalisable to patient types that were not included (such as those in general hospitals). However, for the purposes of obtaining an estimate of the AMR percentage in a target population of ICU patients in tertiary-care facilities (to develop empirical therapy guidelines for this specific population, for example), a sample of ICU patients from a selection of tertiary-care facilities in the country would probably result in a fairly unbiased estimate. In other words, the conclusion as to whether results obtained in a sample are biased depends on the target population of interest.

Data quality by country

To be able to evaluate the quality and representativeness of data from individual countries presented in this report, Table A3.2 presents information on coverage of the surveillance system, data representativeness and blood culture rate, by country.

Table A3.1 Common sources of error and bias in antimicrobial resistance surveillance data

Type of error/bias		Mechanism	Solution
Random error	Sampling variation	Natural variation between patients.	Increase sample size.
	Measurement variation	Test-to-test variation in application of laboratory procedures.	Increase sample size. Standardise procedures. Provide continuous training of laboratory staff. Set up quality-assurance systems.
Systematic error	**Bias related to sampling**		
	Selection of participating sites	Selecting sites for specific patient populations only, such as specialised or tertiary-care hospitals in urban areas.	Select a mixture of hospital types from different geographical regions.
	Selection of patients	Sampling of severe cases only, patients with treatment failure, or patients strongly suspected of having a resistant infection.	Improve case ascertainment: promote sampling of all cases with signs of bloodstream infection or meningitis from all types of hospital departments and prior to treatment initiation (active case-finding).
	Timing of sampling	Sampling cases over a limited period of time.	Sample cases continuously throughout the year.
	Bias related to laboratory procedures		
	Measurement error	Improper application of laboratory methods, such as errors in preparing media for disk diffusion. Use of inadequate laboratory materials, such as expired or non-quality-controlled antimicrobial disks. Damaged and/or poorly calibrated equipment, such as out-of-date firmware used with automated systems.	Provide continuous training of laboratory staff. Procure high-quality and quality-controlled materials and consider expiration dates. Set up and implement laboratory quality-assurance systems. Perform confirmatory testing of isolates with rare or unusual AMR, or with AMR phenotypes of consequence to clinical practice.
	AST procedures and interpretation	Use of non-uniform AST methods, such as out-of-date guidelines. Use of different expert rules across laboratories for interpretation of AST. Sequential or differential testing of antibiotics, such as testing susceptibility for carbapenems only if isolate is resistant to third-generation cephalosporins.	Use national standards based on international guidelines for AST (such as EUCAST). Collect crude quantitative data. Test susceptibility to all indicator antimicrobials (uniform test panel) for all isolates.
	Bias related to data analysis procedures		
	Selection of isolates	Inclusion of follow-up isolates from individual patients.	Use standardised data-analysis methods with the aim of achieving equal representation of all patients in the data.

Table A3.2 Population and hospitals contributing data: coverage, representativeness and blood culture rate, WHO European Region, 2021 (or latest available data)

Country	Estimated national population coverage[a] (%)	Geographical representativeness[b]	Hospital representativeness[c]	Isolate representativeness[d]	Blood culture rate (blood culture sets/1 000 patient-days)[e]
EU/EEA					
Austria	ND	High	High	High	ND
Belgium	43[f]	High	High	High	100.8[f]
Bulgaria	45	Medium	Medium	Medium	11.4
Croatia	100	High	High	High	38.3
Cyprus	75	High	High	High	73.8
Czechia	80	High	High	High	21.3
Denmark	100	High	High	High	251.0
Estonia	100	High	High	High	39.2
Finland	96	High	High	High	143.9
France	55[g]	High	High	High	54.6[g]
Germany	35	High	Medium	High	ND
Greece	42	High	High	Medium	ND
Hungary	90	High	High	High	22.0
Iceland	100	High	High	High	64.4
Ireland	96	High	High	High	56.5
Italy	61	High	High	High	66.6
Latvia	90	High	Medium	Medium	17.0
Liechtenstein	ND	ND	ND	ND	ND
Lithuania	100	High	High	High	9.8
Luxembourg	100	High	High	High	42.1
Malta	95	High	High	High	37.7
Netherlands	68	High	High	High	ND
Norway	94	High	High	High	87.4
Poland	20	Medium	Medium	High	54.7
Portugal	97	High	High	High	256.0
Romania	6	Low	Low	Low	32.7
Slovakia	56	High	High	High	32.1
Slovenia	99	High	High	High	46.8
Spain	31	Medium	High	High	165.4
Sweden	89	High	High	High	ND
WHO European Region (excluding EU/EEA)					
Albania	ND	ND	ND	ND	ND
Andorra	ND	ND	ND	ND	ND
Armenia	ND	Low	Low	Low	6 (2-10)
Azerbaijan	ND	ND	ND	ND	ND
Belarus	99	High	High	Low	8 (0-416)
Bosnia and Herzegovina	77	High	High	Medium	19 (6-52)
Georgia	80	High	High	Low	14 (0-204)
Israel	ND	ND	ND	ND	ND
Kazakhstan	ND	Low	Low	Low	12 (3-21)
Kyrgyzstan	ND	ND	ND	ND	ND
Moldova	49	High	High	Low	4 (0-12)
Monaco	ND	ND	ND	ND	ND
Montenegro	100	High	High	Low	6 (1-17)
North Macedonia	100	High	High	Low	ND
Russia	ND	High	Low	Low	16 (1-46)
Serbia	NA	NA	NA	NA	NA
Serbia excluding Kosovo[h]	78	High	High	Medium	23 (1-117)
Kosovo[h]	59	Medium	Low	Low	7
Switzerland	89	High	High	High	ND
Tajikistan	ND	ND	ND	ND	ND
Türkiye	28	High	High	Medium	42 (3-133)
Turkmenistan	11	Low	Low	Low	ND
Ukraine	10	Medium	High	Low	5 (0-25)
United Kingdom	32	Medium	High	High	51 (0-187)
Uzbekistan	ND	ND	ND	ND	ND

Table A3.2 contd

Note: European Region comprises the 53 countries of the WHO European Region and Liechtenstein.
ND: no data available.
NA: not applicable.
[a] For EARS-Net, as estimated by ECDC's national focal points for AMR and/or operational contact points for AMR. Estimated national population coverage: mean population coverage (%) of laboratories capable of reporting *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterococcus faecalis* and *Enterococcus faecium*. Due to outliers in some countries, *Streptococcus pneumoniae* and *Acinetobacter* species are not included in the calculation. For CAESAR, an estimate of the population coverage is based on the best estimates of the overall catchment population of the hospitals included in the AMR surveillance network, as reported by the WHO AMR focal point.
[b] Geographical representativeness. High: all main geographical regions of the country are covered. Medium: most geographical regions of the country are covered. Low: only a few geographical areas of the country are covered. ND: no data available.
[c] Hospital representativeness. High: the hospital selection is representative of the acute care hospital distribution in the country. Medium: the hospital selection is partly representative of the acute care hospital distribution in the country. Low: the hospital selection is poorly representative of the acute care hospital distribution in the country.
[d] Isolate representativeness. High: the isolate selection is representative of microorganisms causing invasive infections in the included hospitals. Medium: the isolate selection is partly representative of microorganisms causing invasive infections in the included hospitals. Low: the isolate selection is poorly representative of microorganisms causing invasive infections in the included hospitals. ND: no data available.
[e] Blood culture rate, blood culture sets/1 000 patient-days: refers to the number of blood culture sets per 1 000 patient-days in hospitals served by EARS-Net/CAESAR laboratories, and sent to these laboratories. The definition of a blood culture set and a patient-day might differ between and within countries and influence the estimate. Blood culture rates are presented as the number of blood culture sets taken per 1 000 patient-days in hospitals providing AMR data. For EARS-Net this is calculated by dividing the mean of the blood culture sets with the mean total number of patient-days of hospitals served by laboratories that provided the number of blood culture sets performed for the following bacterial species: *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterococcus faecalis* and *Enterococcus faecium*. For CAESAR, this is calculated in a similar manner to EARS-Net, with the exception that *S. pneumoniae* and *Acinetobacter* spp. are included in the calculation, and with the range in individual hospitals included in parentheses. When the range is not presented, data apply to one hospital only.
[f] Not including *Streptococcus pneumoniae* network.
[g] The *S. pneumoniae* network is not included. It has an estimated population coverage of 56%. Its surveillance protocol does not prescribe reporting of the number of blood culture sets.
[h] This designation is without prejudice to positions on status, and is in line with UN Security Council Resolution 1244 and the International Court of Justice Opinion on the Kosovo Declaration of Independence.

Recommended reading

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Rempel OR, Laupland KB. Surveillance for antimicrobial resistant organisms: potential sources and magnitude of bias. Epidemiol Infect. 2009;137(12):1665–73.

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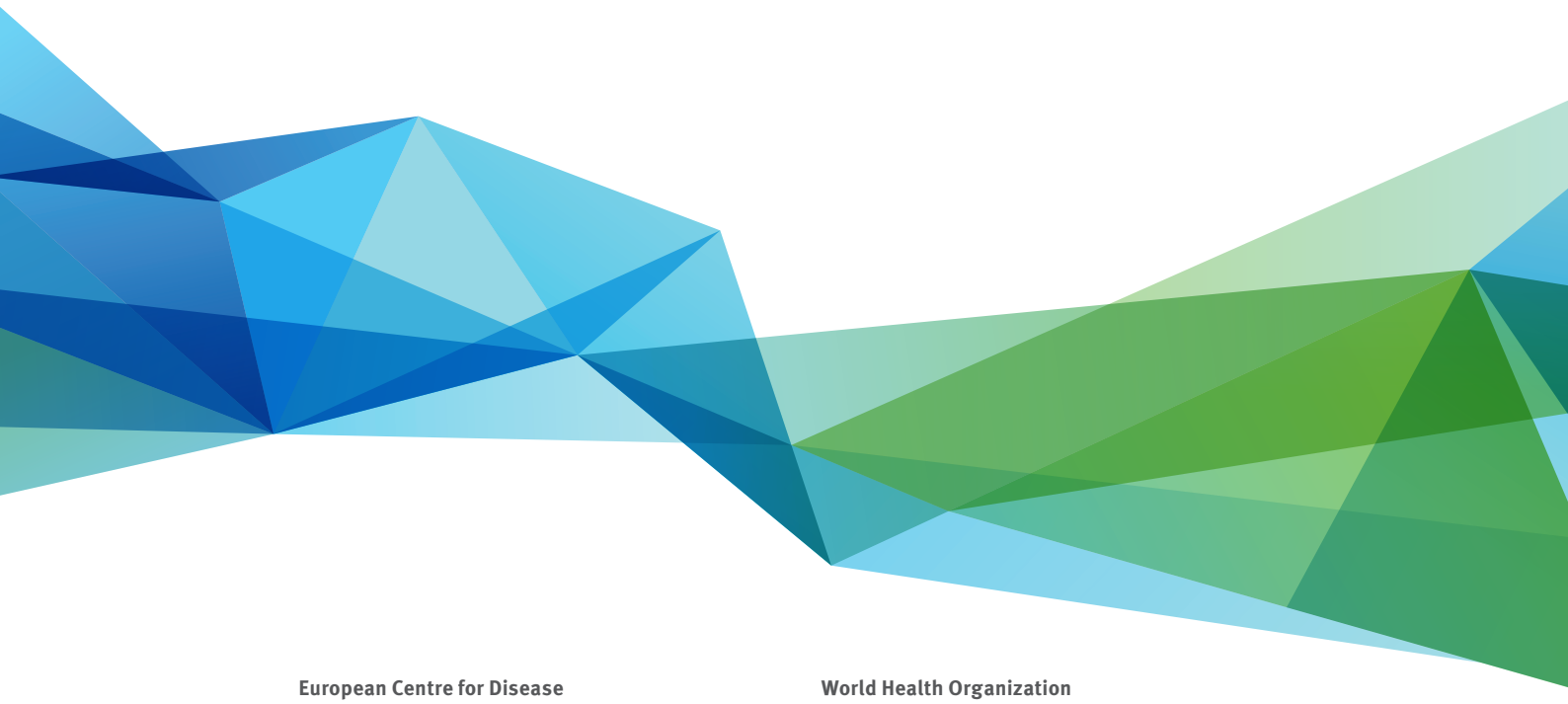

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