

Surveillance Atlas Information about the Data

Antimicrobial resistance

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Antimicrobial resistance in *Acinetobacter* species

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Acinetobacter* species collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Surveillance is restricted to genus level (i.e. *Acinetobacter* spp) due to the difficult species identification. Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

Routine antimicrobial susceptibility test (AST) results are collected from clinical laboratories by the national network representative in each participating country. For a comprehensive list of all national institutions and organisations participating in EARS-Net, please refer to the [EARS-Net annual report](#). National data are uploaded annually by the national data manager to The European Surveillance System (TESSy) at ECDC. Data published in the Surveillance Atlas might differ from figures in national reports due to different times of reporting, inclusion of cases by different case definitions and use of different denominators.

The panels of antimicrobial agent combinations under surveillance are defined in the [EARS-Net reporting protocol](#). In addition, the [EUCAST guidelines for detection of resistance mechanisms and specific types of resistance of clinical and/or epidemiological importance](#) have been developed to describe the mechanisms of resistance and recommended methods of detection for key EARS-Net bacterium-antimicrobial group combinations.

For more information on EARS-Net data collection, results and data interpretation, please refer to the latest [EARS-Net reporting protocol](#) and the [EARS-Net annual report](#).

Surveillance Atlas indicators

The Surveillance Atlas displays *Acinetobacter* spp susceptibility data for the following antimicrobial groups: fluoroquinolones, aminoglycosides, carbapenems and combined resistance (fluoroquinolones, aminoglycosides and carbapenems). The antimicrobial agents included in each antimicrobial group are defined in Table 1.

Table 1: Antimicrobial group combinations for *Acinetobacter* species

Antimicrobial group	Agents included
Fluoroquinolones	Ciprofloxacin and levofloxacin
Aminoglycosides	Gentamicin, netilmicin and tobramycin
Carbapenems	Meropenem and imipenem
Combined (fluoroquinolones, aminoglycosides and carbapenems)	Combined resistance to the fluoroquinolones group, aminoglycosides group and carbapenems group

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

Cases can be stratified in a bar or a pie chart by:

- age group (0-4, 5-18, 19-64, 65 years and above);
- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Stratifications by age group or gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

Table 2: Symbols used in the Surveillance Atlas

Symbol	Comment
-	Indicator is not calculated for a given geographical resolution and time period.
.	Missing data. Data are not reported to TESSy for the related time period.

Antimicrobial resistance in *Escherichia coli*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Escherichia coli* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

Routine antimicrobial susceptibility test (AST) results are collected from clinical laboratories by the national network representative in each participating country. For a comprehensive list of all national institutions and organisations participating in EARS-Net, please refer to the [EARS-Net annual report](#). National data are uploaded annually by the national data manager to The European Surveillance System (TESSy) at ECDC. Data published in the Surveillance Atlas might differ from figures in national reports due to different times of reporting, inclusion of cases by different case definitions and use of different denominators.

The panels of antimicrobial agent combinations under surveillance are defined in the [EARS-Net reporting protocol](#). In addition, the [EUCAST guidelines for detection of resistance mechanisms and specific types of resistance of clinical and/or epidemiological importance](#) have been developed to describe the mechanisms of resistance and recommended methods of detection for key EARS-Net bacterium-antimicrobial group combinations.

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Surveillance Atlas indicators

The Surveillance Atlas displays *E. coli* susceptibility data for the following antimicrobial groups: aminopenicillins, fluoroquinolones, third-generation cephalosporins, aminoglycosides, carbapenems and combined resistance (fluoroquinolones, third-generation cephalosporins and aminoglycosides). The antimicrobial agents included in each antimicrobial group are defined in Table 1.

Table 1: Antimicrobial group combinations for *E. coli*

Antimicrobial group	Agents included
Aminopenicillins	Ampicillin and amoxicillin
Fluoroquinolones	Ciprofloxacin, levofloxacin or ofloxacin
Third-generation cephalosporins	Cefotaxime, ceftriaxone and ceftazidime
Aminoglycosides	Gentamicin, tobramycin or netilmicin
Carbapenems	Meropenem and imipenem
Combined (fluoroquinolones, third-generation cephalosporins and aminoglycosides)	Combined resistance to the fluoroquinolones group, third-generation cephalosporins group and aminoglycosides group

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

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- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Indicators by age group and gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

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Antimicrobial resistance in *Enterococcus faecalis*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Enterococcus faecalis* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

Routine antimicrobial susceptibility test (AST) results are collected from clinical laboratories by the national network representative in each participating country. For a comprehensive list of all national institutions and organisations participating in EARS-Net, please refer to the [EARS-Net annual report](#). National data are uploaded annually by the national data manager to The European Surveillance System (TESSy) at ECDC. Data published in the Surveillance Atlas might differ from figures in national reports due to different times of reporting, inclusion of cases by different case definitions and use of different denominators.

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Surveillance Atlas indicators

The Surveillance Atlas displays *E. faecalis* susceptibility data for the following antimicrobial groups: aminopenicillins, high-level gentamicin and vancomycin. The antimicrobial agents included in each antimicrobial group are defined in Table 1.

Table 1: Antimicrobial group combinations for *E. faecalis*

Antimicrobial group	Agents included
Aminopenicillins	Ampicillin and amoxicillin
High-level gentamicin	Gentamicin-high*
Vancomycin	Vancomycin

** Enterococci are intrinsically resistant to aminoglycosides and aminoglycoside monotherapy is ineffective. There is likely to be synergy between aminoglycosides and penicillins or glycopeptides against enterococci without acquired high-level resistance. All testing is therefore to distinguish between intrinsic and high-level acquired resistance.*

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

Cases can be stratified in a bar or a pie chart by:

- age group (0-4, 5-18, 19-64, 65 years and above);
- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Indicators by age group and gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

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Antimicrobial resistance in *Enterococcus faecium*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Enterococcus faecium* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

Routine antimicrobial susceptibility test (AST) results are collected from clinical laboratories by the national network representative in each participating country. For a comprehensive list of all national institutions and organisations participating in EARS-Net, please refer to the [EARS-Net annual report](#). National data are uploaded annually by the national data manager to The European Surveillance System (TESSy) at ECDC. Data published in the Surveillance Atlas might differ from figures in national reports due to different times of reporting, inclusion of cases by different case definitions and use of different denominators.

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Surveillance Atlas indicators

The Surveillance Atlas displays *E. faecium* susceptibility data for the following antimicrobial groups: aminopenicillins, high-level gentamicin and vancomycin. The antimicrobial agents included in each antimicrobial group are defined in Table 1.

Table 1: Antimicrobial group combinations for *E. faecium*

Antimicrobial group	Agents included
Aminopenicillins	Ampicillin and amoxicillin
High-level gentamicin	Gentamicin-high*
Vancomycin	Vancomycin

** Enterococci are intrinsically resistant to aminoglycosides and aminoglycoside monotherapy is ineffective. There is likely to be synergy between aminoglycosides and penicillins or glycopeptides against enterococci without acquired high-level resistance. All testing is therefore to distinguish between intrinsic and high-level acquired resistance.*

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

Cases can be stratified in a bar or a pie chart by:

- age group (0-4, 5-18, 19-64, 65 years and above);
- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Indicators by age group and gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

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Antimicrobial resistance in *Klebsiella pneumoniae*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Klebsiella pneumoniae* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

Routine antimicrobial susceptibility test (AST) results are collected from clinical laboratories by the national network representative in each participating country. For a comprehensive list of all national institutions and organisations participating in EARS-Net, please refer to the [EARS-Net annual report](#). National data are uploaded annually by the national data manager to The European Surveillance System (TESSy) at ECDC. Data published in the Surveillance Atlas might differ from figures in national reports due to different times of reporting, inclusion of cases by different case definitions and use of different denominators.

The panels of antimicrobial agent combinations under surveillance are defined in the [EARS-Net reporting protocol](#). In addition, the [EUCAST guidelines for detection of resistance mechanisms and specific types of resistance of clinical and/or epidemiological importance](#) have been developed to describe the mechanisms of resistance and recommended methods of detection for key EARS-Net bacterium-antimicrobial group combinations.

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Surveillance Atlas indicators

The Surveillance Atlas displays *K. pneumoniae* susceptibility data for the following antimicrobial groups: fluoroquinolones, third-generation cephalosporins, aminoglycosides, carbapenems and combined resistance (fluoroquinolones, aminoglycosides and carbapenems). The antimicrobial agents included in each antimicrobial group are defined in Table 1.

Table 1: Antimicrobial group combinations for *K. pneumoniae*

Antimicrobial group	Agents included
Fluoroquinolones	Ciprofloxacin, levofloxacin and ofloxacin
Third-generation cephalosporins	Cefotaxime, ceftriaxone and ceftazidime
Aminoglycosides	Gentamicin, netilmicin and tobramycin
Carbapenems	Meropenem and imipenem
Combined (fluoroquinolones, third-generation cephalosporin and aminoglycosides)	Combined resistance to the fluoroquinolones group, third-generation cephalosporins group and aminoglycosides group

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

Cases can be stratified in a bar or a pie chart by:

- age group (0-4, 5-18, 19-64, 65 years and above);
- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Indicators by age group and gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

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Antimicrobial resistance in *Pseudomonas aeruginosa*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Pseudomonas aeruginosa* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

Routine antimicrobial susceptibility test (AST) results are collected from clinical laboratories by the national network representative in each participating country. For a comprehensive list of all national institutions and organisations participating in EARS-Net, please refer to the [EARS-Net annual report](#). National data are uploaded annually by the national data manager to The European Surveillance System (TESSy) at ECDC. Data published in the Surveillance Atlas might differ from figures in national reports due to different times of reporting, inclusion of cases by different case definitions and use of different denominators.

The panels of antimicrobial agent combinations under surveillance are defined in the [EARS-Net reporting protocol](#). In addition, the [EUCAST guidelines for detection of resistance mechanisms and specific types of resistance of clinical and/or epidemiological importance](#) have been developed to describe the mechanisms of resistance and recommended methods of detection for key EARS-Net bacterium-antimicrobial group combinations.

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Surveillance Atlas indicators

The Surveillance Atlas displays *P. aeruginosa* susceptibility data for the following antimicrobial groups: piperacillin + tazobactam, ceftazidime, fluoroquinolones, aminoglycosides, carbapenems and combined resistance to at least three antimicrobial groups out of piperacillin + tazobactam, ceftazidime, fluoroquinolone, aminoglycoside and carbapenem resistance. The antimicrobial agents included in each antimicrobial group are defined in Table 1.

Table 1: Antimicrobial group combinations for *P. aeruginosa*

Antimicrobial group	Agents included
Piperacillin+tazobactam	Piperacillin+tazobactam
Ceftazidime	Ceftazidime
Fluoroquinolones	Ciprofloxacin or levofloxacin
Aminoglycosides	Gentamicin, tobramycin or netilmicin
Carbapenems	Meropenem and imipenem
Combined (\geq three antimicrobial groups out of piperacillin+tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems)	Combined resistance to at least three antimicrobial groups out of piperacillin+tazobactam, ceftazidime, fluoroquinolones, aminoglycosides and carbapenems

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

Cases can be stratified in a bar or a pie chart by:

- age group (0-4, 5-18, 19-64, 65 years and above);
- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Indicators by age group and gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

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Antimicrobial resistance in *Staphylococcus aureus*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Staphylococcus aureus* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

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Surveillance Atlas indicators

The Surveillance Atlas displays *S. aureus* data for meticillin (MRSA). The hierarchical level to define MRSA including confirmation tests and antimicrobial agents included in the group are defined in Table 1. Confirmation test results have priority over antimicrobial susceptibility test results.

Table 1: Hierarchical level to assess MRSA

Hierarchical level to determine MRSA status	Tests and antimicrobial agents included	Interpretation
1. Confirmation test available	Detection of PCR <i>mecA</i> -gene or positive PBP2A-agglutination test	If at least one test is positive, then MRSA If one test is negative and the other not positive, then not MRSA
2. Only antimicrobial susceptibility test available	Cefoxitin, cloxacillin, dicloxacillin, flucloxacillin, meticillin, oxacillin	If SIR = S, then not MRSA If SIR = I or R, then MRSA

For each of the antimicrobial groups, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number

Historically, EARS-Net encouraged the use of clinical breakpoints as defined by the [European Committee on Antimicrobial Susceptibility Testing \(EUCAST\)](#) in accordance with the [EU case definition for AMR](#), results based on other interpretive criteria has been accepted. Starting with data collected for the year 2019, only results generated with methods and breakpoints from EUCAST are accepted.

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- age group (0-4, 5-18, 19-64, 65 years and above);
- gender

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Antimicrobial resistance in *Streptococcus pneumoniae*

Data source

The Surveillance Atlas of Infectious Diseases displays data on antimicrobial resistance in *Streptococcus pneumoniae* collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net). Only data from invasive (blood and cerebrospinal fluid) isolates are included in EARS-Net.

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Surveillance Atlas indicators

The Surveillance Atlas displays *S. pneumoniae* susceptibility data for the following antimicrobial groups: penicillins, macrolides and combined resistance to penicillins and macrolides. The antimicrobial agents included in each antimicrobial group and the hierarchical level to define penicillin susceptibility are defined in Table 1.

The indicator penicillin non-wild-type refers to *S. pneumoniae* isolates reported by the local laboratories as 'susceptible, increased exposure' (I) or resistant (R) to penicillin, assuming MICs to benzylpenicillin above those of the wild-type isolates, i.e. >0.06 mg/L. The analysis is based on the qualitative susceptibility categories S, I and R as quantitative susceptibility information was missing for a large proportion of the data.

Table 1: Antimicrobial group combinations for *S. pneumoniae* including hierarchical levels for determining penicillin susceptibility.

Antimicrobial group	Tests and antimicrobial agents included	Hierarchical level to determine susceptibility
Penicillins	Penicillin and oxacillin	If both penicillin and oxacillin susceptibility results are reported, priority is given to penicillin
Macrolides	Erythromycin, clarithromycin or azithromycin	-

For penicillins, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Penicillin non-wild-type isolates*, percentage
3. Total tested isolates, number
4. R- resistant isolates, number
5. I- 'susceptible, increased exposure' isolates, number
6. S- susceptible isolates, number

For macrolides, the following indicators are available in the Surveillance Atlas:

1. R- resistant isolates, percentage
2. Total tested isolates, number
3. R- resistant isolates, number
4. I- 'susceptible, increased exposure' isolates, number
5. S- susceptible isolates, number

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- gender

If AST results for a specific antimicrobial group were reported for fewer than 10 isolates in a country and a given year, no percentages of non-susceptible and resistant isolates are calculated.

Indicators by age group and gender are not displayed if more than 50% of cases have undocumented information (unknown or missing) for a given geographical resolution (e.g. country) and time period.

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Interpretation

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

Population coverage

Population coverage varies among reporting countries. Some countries report data from large national surveillance systems with a high coverage, while other countries report data from a smaller subset of local laboratories and hospitals. The population under surveillance is not constant and may change over the years due to variations in the number of participating laboratories.

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

Sampling

EARS-Net data are exclusively based on invasive isolates from blood or cerebrospinal fluid. This restriction prevents some of the inconsistencies that arise from differences in clinical case definitions, different sampling frames or heterogeneous healthcare utilisation that would otherwise bias the data analysis. However, invasive isolates may not be representative of isolates of the same bacterial species from other infection sites, i.e. urinary tract infections, pneumonia, wound infections, etc.

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

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

Laboratory routines and capacity

The use of guidelines for clinical breakpoints has varied among countries in Europe, and in some instances between laboratories in the same country. Over time, many European laboratories have changed from using Clinical and Laboratory Standards Institute (CLSI) to EUCAST clinical guidelines, and as of the data collected for 2019 only data based on EUCAST clinical guidelines are included in the EARS-Net surveillance. As a result, the interpretation of AST results may vary over time, and, before 2019, between and within countries, at least for resistance mechanisms resulting in minimum inhibitory concentrations (MICs) close to the breakpoints.

In addition, clinical breakpoints may change over time, as breakpoints may be revised. As quantitative data (i.e. disk diffusion zone diameters or MIC values) are not provided by all participating laboratories, only the reported S, I, and R results are considered for the analyses.

The ability to identify the microorganism and its associated antimicrobial susceptibility pattern may differ among laboratories and over time. All laboratories providing data for EARS-Net are offered participation in an annual External Quality Assessment (EQA) to assess the reliability of the laboratory test results. For more information on the EARS-Net EQA and laboratory performance, see the latest EARS-Net EQA report.