
# Global Antimicrobial Resistance Surveillance System (GLASS) Report

## Early implementation

2016-2017

World Health Organization

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# Content

# SUMMARY

Antimicrobial resistance (AMR) is a critical public health issue globally. If we are to preserve human and animal health, policy interventions and global collaboration are vital to improve our understanding of AMR dynamics and to inform containment and mitigation strategies.

On 22 October 2015 WHO launched the Global Antimicrobial Resistance Surveillance System (GLASS), the first global collaborative effort to standardise AMR surveillance. GLASS supports the strategic objective of WHO's Global Action Plan on AMR (GAP-AMR) to strengthen the AMR evidence base. GLASS provides a standardised approach to the collection, analysis, and sharing of AMR data by countries, and seeks to document the status of existing or newly developed national AMR surveillance systems. GLASS is supported by WHO Collaborating Centres, involving strong commitment from participating countries and close collaborations with AMR regional networks.

In addition to the collection of data, GLASS helps to foster and strengthen national AMR surveillance systems in order to ensure the production of reliable information. Furthermore, GLASS promotes a shift from surveillance approaches based solely on laboratory data (isolate-based data) to a system that includes epidemiological, clinical, and population-level data. This approach has been shown to increase the understanding of the impact of AMR on human health and to enable better analysis and prediction of AMR trends.

In its early implementation phase (2015-2019), GLASS aims to combine data on the status of enrolled countries' AMR surveillance systems with AMR data for selected bacteria that cause infections in humans: *Acinetobacter* spp., *Escherichia coli*, *Klebsiella pneumoniae*, *Neisseria gonorrhoeae*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, and *Streptococcus pneumoniae*. AMR data are collected through a case-finding surveillance system, which collates results of priority specimens from blood, urine, stool, as well as cervical and urethral specimens, that have been sent routinely to laboratories for clinical purposes. Population data are also collected, including the overall number of patients tested per specific specimen, and variables such as age, gender, and infection origin. The latter is used as proxy to define where the infection has been contracted (hospital versus community).

By the end of the first GLASS data call on 8 July 2017, 42 countries enrolled in GLASS, of which 40 countries provided information on their AMR surveillance systems, and 22 provided 2016 AMR data. The aim of this report is to document participation efforts and outcomes across enrolled countries, and highlight differences and constraints identified to date. The first GLASS data call involved a substantial amount of work for participating countries, particularly for those that had not yet shared AMR data with international systems. Challenges countries faced in reporting data have been taken into consideration in the analysis – for example, included data vary considerably in terms of quality and completeness, so no attempt has been made to compare AMR status at a regional or country level. However, these data enable us to better understand surveillance capacities and mechanisms of reporting across countries, and will enable us to refine GLASS methodology going forward. This work represents a first attempt to report official national AMR data for key pathogens to a global system using standardised surveillance methodology.

GLASS supports the development of three essential core components for national AMR surveillance: a National Coordination Centre (NCC), a National Reference Laboratory (NRL), and sentinel surveillance sites where both diagnostic results and epidemiological data are collected. The core components are linked together by a constant flow of data and information exchange, and work together to building an effective network for detection and monitoring AMR in clinical samples. Based on the information submitted in this data call, almost all countries that have enrolled in GLASS have in place, or are working to establish, a system that includes these three core components. National AMR surveillance plans have been introduced in most of the enrolled countries enrolled in GLASS, and surveillance National Focal Points (NFPs) have been identified in all countries, working closely with the GLASS Secretariat alongside WHO Regional Offices, Country Offices, and regional networks. AMR surveillance sites (reporting to national surveillance systems) currently vary by country in terms of number of facilities and type of facility (hospital versus outpatient clinics). Although not all surveillance sites are yet reporting to GLASS, a structure is in place to ensure that they will be incorporated into future data calls. Almost all surveillance sites are supported by local clinical laboratories performing antimicrobial susceptibility testing (AST) according to internationally recognised standards (either European Committee on Antimicrobial Susceptibility Testing (EUCAST), the Clinical and Laboratory Standards Institute (CLSI), or other recognised protocols). In most

countries currently reporting AMR data to GLASS, AST and bacterial identification are quality controlled, with external quality assurance (EQA) provided to local clinical laboratories by national AMR surveillance programmes. Moreover, most NRLs, whose role is to coordinate and support diagnostic providers at the surveillance sites, participate in international EQA schemes.

In this data call, countries provided AMR data primarily for pathogens isolated from blood specimens, followed by urine, stool, cervical and urethral ones. The total number of isolates with submitted AST results varied considerably, from a minimum of 72 isolates per country to a maximum of 167,331 (for countries combined total of 507,746 isolates). Only one country[1] submitted data on all selected pathogens. The most frequently reported were resistance patterns for *E. coli*, *K. pneumoniae*, *S. aureus*, and *S. pneumoniae* (17 countries among the 22 countries reporting AMR rates), followed by resistance patterns for *Salmonella* spp. (15 countries). AST results for *N. gonorrhoeae* and *Shigella* spp. were compiled by 11 and eight countries, respectively. AST data submission for GLASS involves 12 antimicrobial classes, with 73% of countries providing results for more than half of the antibiotics requested. Five countries[2] also submitted data on the total sampled population (see 2.2.3 for the description of GLASS methodology and approach), enabling the incidence of occurrence of resistance within tested populations to be calculated and, in some cases, stratified for gender, age, and infection origin.

GLASS is now working towards the integration of surveillance initiatives for AMR in bacterial pathogens. In this report we highlight a series of modules now being created to facilitate this integration. These include modules on antimicrobial consumption (AMC), the enhanced Gonococcal Antimicrobial Surveillance Programme, and AMR in the food chain. These surveillance modules will be added to the GLASS IT platform to allow the collection, analysis, and reporting of diverse cross-sectoral AMR data into a single repository.

Despite the limitations and constraints encountered during the first GLASS data call, the information included in this report represents a first step towards improving our understanding of the epidemiology and impact of AMR globally. Some countries still face huge challenges to building their national surveillance systems and improvements are still urgently needed. A global system such as GLASS can succeed only through continued data sharing as well as global collaboration, harmonisation, and coordination between all partners involved in the implementation of AMR surveillance.

1 Republic of Korea
2 Latvia, Finland, Republic of Korea, South Africa, and Thailand

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# ABBREVIATIONS

| | |
|---|---|
| AFR | WHO African Region |
| AGISAR | WHO Technical Advisory Group on Integrated Surveillance of Antimicrobial Resistance |
| AMC | Antimicrobial consumption |
| AMR | Antimicrobial resistance |
| AMR | WHO Region of the Americas |
| AST | Antimicrobial susceptibility testing |
| CAESAR | Central Asian and Eastern European Surveillance of Antimicrobial Resistance |
| CI | Confidence interval |
| CLSI | Clinical and Laboratory Standards Institute |
| DDD | Defined daily dose |
| EARS-Net | European Antimicrobial Resistance Surveillance Network |
| ECDC | European Centre for Disease Prevention and Control |
| EFSA | European Food Safety Authority |
| EMR | WHO Eastern Mediterranean Region |
| EQA | External quality assessment |
| ESAC-Net | ECDC European Surveillance of Antimicrobial Consumption Network |
| ESBL | Extended spectrum beta-lactamase |
| EUCAST | European Committee on Antimicrobial Susceptibility Testing |
| EUR | WHO European Region |
| FAO | Food and Agriculture Organization of the United Nations |
| GAP-AMR | Global Action Plan on Antimicrobial Resistance |
| GLASS | Global Antimicrobial Resistance Surveillance System |
| GASP | Gonococcal Antimicrobial Surveillance Programme |
| HCF | Health-care facilities |
| HIV/AIDS | Human immunodeficiency virus/acquired immune deficiency syndrome |
| MIC | Minimum inhibitory concentration |
| MRSA | Methicillin-resistant *Staphylococcus aureus* |
| NCC | National coordinating centre |
| NFP | National focal point |
| NRL | National reference laboratory |
| OECD | Organization for Economic Co-operation and Development |
| OIE | World Organisation for Animal Health |
| ReLAVRA | Red Latinoamericana de Vigilancia de la Resistencia Antimicrobiana |
| RIS | Resistant, intermediate, susceptible |
| RO | WHO Regional Offices |
| SEAR | WHO South-East Asia Region |
| UNGA | United Nations General Assembly |
| WPR | WHO Western Pacific Region |
| WHA | World Health Assembly |

## WHO Regional offices

| | |
|---|---|
| AFRO | WHO Regional Office for Africa |
| AMRO/PAHO | WHO Regional Office for the Americas/Pan American Health Organization |
| EMRO | WHO Regional Office for the Eastern Mediterranean |
| EURO | WHO Regional Office for Europe |
| SEARO | WHO Regional Office for South-East Asia |
| WPRO | WHO Regional Office for the Western Pacific |


SECTION
01

# Introduction

## 1.1 The global impact of antimicrobial resistance (AMR) on human health

The discovery of antimicrobials has been an important driver for unprecedented medical and societal advances [1]. Less than a century ago patients were still dying from infectious diseases that are completely treatable today [2]. Modern medical achievements, such as major surgery, organ transplants, treatment of preterm babies, or cancer chemotherapy, would not be possible without the existence of effective antimicrobial treatments [3]. However, new AMR mechanisms are emerging and spreading globally, threatening our ability to treat infectious diseases, resulting in prolonged illness, disability, and death, and increasing the cost of health care.

Antimicrobial-resistant organisms are found in people, food, animals, plants, and the environment (in water, soil, and air) and they can move between ecosystems [4]. AMR occurs naturally and over time when microorganisms (such as bacteria, fungi, viruses, and parasites) are exposed to antimicrobial substances [4]. As a result, treatments become ineffective and infections persist in the body, increasing the risk of spread to others [4]. Although the emergence of AMR is a natural phenomenon, the misuse and overuse of antimicrobials is accelerating this process [5].

Rigorous policy interventions to tackle AMR are paramount and global collaboration is necessary to improve the understanding of AMR dynamics and to inform containment and mitigation strategies to preserve human and animal health, and the environment.

## 1.2 Development of global AMR initiatives

In view of the growing threat to public health, impact on the world economy, and recognised need for concerted action, WHO has initiated a range of AMR-related activities [6]. In 2001, WHO issued the Global Strategy for Containment of AMR and several resolutions were approved by WHO Member States to address the strategy objectives [7, 8]. Although the Global Strategy was not implemented comprehensively at global level, it inspired a number of national and regional AMR strategies in the following years. In 2008, WHO established the Technical Advisory Group on Integrated Surveillance of Antimicrobial Resistance (AGISAR) to advise WHO on AMR surveillance in the food chain, making antibacterial resistance a timely One Health issue [9]. Afterwards, AMR was the focus of World Health Day 2011, during which WHO delivered a six-point AMR policy package calling for action by all global stakeholders [10]. In November 2011, the tripartite collaboration between the Food and Agriculture Organization (FAO) of the United Nations, the World Organisation for Animal Health (OIE), and WHO defined AMR as a priority issue to be addressed within health risks at the human–animal-plant-ecosystem interface [11]. Finally, the Global Action Plan on Antimicrobial Resistance (GAP-AMR), set up to tackle AMR at a global level, was approved by the WHO 68th World Health Assembly in May 2015. It was developed with the broad participation of stakeholders from different sectors and in close partnership with FAO and OIE [12]. These two organizations endorsed the GAP-AMR at their respective general assemblies in 2015.

The goal of the GAP-AMR is "to ensure, for as long as possible, continuity of successful treatment and prevention of infectious diseases with effective and safe medicines that are quality-assured, used in a responsible way, and accessible to all who need them" [12]. The plan sets out five strategic objectives:

- Improve awareness and understanding of AMR;
- Strengthen knowledge through surveillance and research;
- Reduce the incidence of infection;
- Optimise the use of antimicrobial agents; and
- Develop the economic case for sustainable investment through research and development.

## 1.3 Role of harmonised Global AMR surveillance

Surveillance is an essential tool to inform policies and infection control and prevention responses, and is the cornerstone for assessing the spread of AMR and informing and monitoring the impact of local, national, and global strategies. Global surveillance systems for HIV, influenza, malaria, and tuberculosis

have monitored resistance in specific pathogens for many years [13-16]. Large regional AMR surveillance networks have been established in Europe (ECDC European Antimicrobial Resistance Surveillance Network, EARS-Net [17]), Central Asia and Eastern Europe (Central Asian and Eastern European Surveillance of Antimicrobial Resistance, CAESAR [18]), and, for the last two decades, in Latin America (Rede Latinoamericana de Vigilancia de la Resistencia a los Antimicrobianos, ReLAVRA [19]).

However, no harmonised system has been put in place to standardise the collection of official AMR data that could offer a clearer and more comprehensive picture of AMR occurrence globally. The 2014 WHO AMR Global Report on Surveillance was the first attempt to assemble accessible information on national AMR surveillance and on AMR data for a set of selected human pathogenic bacteria worldwide, and to examine the evidence base related to the health and economic impact of AMR [20]. Key findings of the report related to AMR in bacterial pathogens were:

1. An observed high ratio of resistance in bacteria among tested isolates in all regions;
2. Significant gaps in surveillance and a lack of global standards for methodology, data sharing, and coordination;
3. The vast majority of data generated did not include sufficient epidemiological and clinical information to inform on the magnitude of AMR in humans; and, most importantly,
4. Country data, when available, were frequently not shared with or recognised by national bodies, limiting the ability to influence national actions.

The 2014 WHO AMR Global Report on Surveillance concluded by highlighting the need for the development of a global surveillance system, based on officially recognised data across countries, to improve the understanding of AMR, inform national effective control strategies, and support regional and global efforts to tackle AMR.


SECTION
02

# GLASS development

## 2.1 Why GLASS?

Driven by the principle that microbes do not respect national boundaries, and that a global perspective is needed to identify events that drive human health conditions, the World Health Assembly (WHA) endorsed the GAP-AMR and requested WHO to establish the Global AMR Surveillance System (GLASS) in resolution WHA68.7 [21]. The results of the 2014 AMR Global Report on Surveillance informed work on development of the global system. On 22 October 2015, GLASS was launched in Copenhagen, Denmark, at a meeting hosted by the WHO Regional Office for Europe (WHO EURO), with the participation of WHO Collaborating Centres, partner technical institutions, and international AMR surveillance networks [20, 22].

GLASS is a system that enables standardised global reporting of official national AMR data. It collaborates with existing regional and national AMR surveillance networks to produce timely and comprehensive data. It is built upon the experience gained by long-standing WHO AMR surveillance programmes, such as tuberculosis (TB) surveillance at global level, and CAESAR and ReLAVRA at a regional level[13, 18, 19]. With the strong support of reporting countries, WHO Regional Offices and Country Offices, and WHO Collaborating Centres, GLASS aims at addressing GAP-AMR's second strategic objective to "strengthen the evidence base through enhanced global surveillance and research." Data collected by GLASS will inform decision-making and provide the evidence base for action and advocacy.

In order to gather and analyse data globally, GLASS relies upon countries to conduct their own national surveillance. GLASS promotes the use of globally agreed and standardised methods for compiling data both locally and nationally, and the gathering of information on selected AMR indicators in a harmonised way across and within countries. As such, through capacity-building and technical assistance, the GLASS Secretariat, Regional and Country Offices, together with AMR regional surveillance networks, support the development and strengthening of national AMR surveillance systems to enhance their capacity to monitor AMR trends and produce reliable and comparable data on a regular basis.

The GLASS objectives are to:

- Foster national surveillance systems and harmonise global standards;
- Estimate the extent of AMR globally by monitoring selected indicators;
- Collect surveillance data needed to inform and estimate AMR burden;
- Routinely analyse and report global data on AMR;
- Detect emerging resistance and its international spread;
- Assess the impact of interventions.

Mindful of the many challenges associated with collecting robust surveillance data, particularly in countries with limited resources, GLASS adopts a stepwise approach to the implementation of national surveillance plans. Any country, at any stage of the development of its national AMR surveillance system, can enrol in GLASS. Countries are encouraged to proceed gradually with the implementation of proposed surveillance standards and indicators based on their national priorities and resources. At the same time, GLASS provides tools for routine surveillance on priority infections in humans [23].

Further, the GLASS IT platform allows for a progressive incorporation of information from other surveillance systems related to AMR in humans, such as AMR in the food chain, monitoring of antimicrobial consumption, targeted surveillance projects, and other AMR-related data. The aim is to encourage and support the multisectoral One Health approach to addressing AMR [24].

## 2.2 GLASS Early implementation phase (2015-2019)

The 2014 WHO AMR Global Report on Surveillance highlighted the absence of a global system for AMR surveillance in bacterial pathogens and fungi [20]. The initial steps of GLASS, therefore, concentrate on AMR and susceptibility in selected bacteria causing infections both in community and in hospitalised patients. Some of the selected bacteria included in GLASS are also present in animals and the food chain, in order to facilitate future links to integrated surveillance systems. An approach for global AMR surveillance in invasive fungal infections will be included in the future steps of GLASS development. The methods and indicators to be applied in GLASS were discussed and agreed at the First High-Level Technical Meeting on Surveillance of Antimicrobial Resistance for Local and Global Action (Public Health

Agency of Sweden, Stockholm, 2014), which was attended by representatives from 30 countries, WHO Collaborating Centres, and representatives from international networks [25]. This consultation informed the GLASS development roadmap, with an early implementation phase covering the period 2015-2019.

The key objectives of this phase are to provide guidance to countries around the development of an effective AMR surveillance system, as well to support the compilation of surveillance data that can be used by policy makers to map out a clearer global picture (GLASS Manual for Early Implementation [26]. At this stage, GLASS facilitates the collection of information on countries' AMR surveillance activities to monitor the status of the national system and to help address potential needs as they arise. GLASS also requires, if available, the submission of AMR data for eight non-specific bacterial pathogens responsible for infections in humans (Section 2.3) from clinical isolates of specimens sent routinely to laboratories.

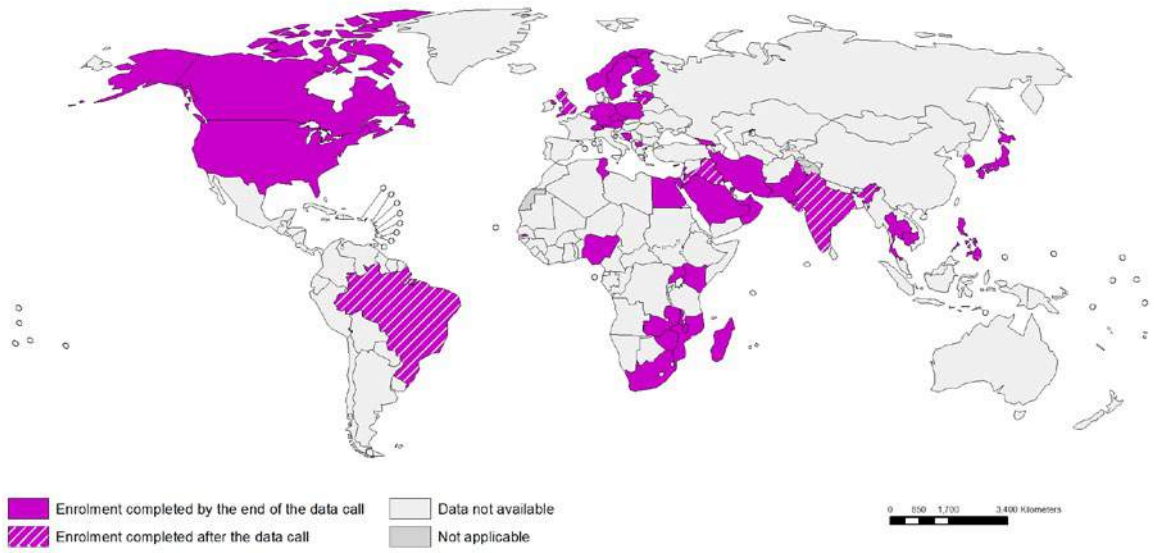
This report summarise official country data submitted to GLASS during its first data call launched on the GLASS WHO website from 1 April – 8 July 2017. Information obtained reported on countries' latest AMR surveillance activities and AMR data for 2016. For countries[1] that submitted data after the end of the data call, results will be available on the GLASS WHO website (www.who.int/glass/).

### 2.2.1 Participation in GLASS

As of 9 December 2017, 50 countries (Fig. 2.1) have enrolled in GLASS, with 42 of these enrolled by the end of the first data call. These include a mix of countries in different stages of economic development (24 high-income countries, nine upper middle-income countries, 11 lower middle-income countries, and six low-income countries) from across all WHO regions.



**Figure 2.1 GLASS Enrolment map (2017)**




In order to enrol, countries submit first an expression of interest to participate in GLASS via the WHO GLASS website (www.who.int/glass/). Then, the country's Ministry of Health or equivalent submits an official nomination letter appointing one national focal point (NFP), and sometimes one additional NFP, to represent the national AMR surveillance programme and be responsible for communication with the GLASS Secretariat (GLASS Guide to enrolment for AMR national focal points [27]). Once the official nomination letter is received, the country is enrolled and the GLASS secretariat provides the NFP and the alternate with the credentials and instructions to access and use the GLASS IT platform.

There is no obligation for countries to provide data on all the information requested during the initial stages, but countries need to commit to developing their AMR surveillance system, and to collecting and sharing data with GLASS. Enrolled countries can start by sending data only on the status of their national surveillance systems before reporting actual AMR data. It is acknowledged that countries might have surveillance systems at various stages of development and for this reason, countries are provided with tailored capacity building IT tools and support for data collection and reporting (Section 2.2.4).

GLASS recommends the establishment of three core components to set up a well-functioning national

[1] Latvia, Finland, Republic of Korea, South Africa, and Thailand

AMR surveillance system; however, countries may enrol and participate in GLASS before any of these components are put in place (GLASS A guide to planning, implementation, and monitoring and evaluation [28]). The three core components include:

1. A national coordinating centre (NCC). The NCC establishes and oversees the national surveillance programme, gathers national AMR data, and communicates with GLASS. A NFP is identified at the outset and serves as the central point of contact within the NCC for all parts of the national surveillance system and GLASS, as well as being responsible for developing links and mechanisms for collaboration with other entities both inside and outside of the country (GLASS Guide to enrolment for AMR national focal points [27]).
2. A national reference laboratory (NRL). The national laboratory oversees antimicrobial susceptibility testing (AST) methods and quality performance of the laboratories supporting surveillance sites participating in the national surveillance system, and serves to investigate unusual or anomalous test results.
3. Surveillance sites. These are usually hospitals, clinics, or outpatient clinics with access to relevant epidemiological and laboratory support. Participating sites are selected by the NCC, and should collect basic demographical, clinical, epidemiological, and microbiological information from patients.

These core components link together through a constant flow of data and information exchange, building an effective network for detection and monitoring of infections and resistance (GLASS Manual for Early Implementation [26])

### 2.2.2 Key pathogens in the GLASS early implementation phase

Eight pathogens were selected as a focus for the GLASS early implementation phase (Annex II):

- *Acinetobacter* spp.
- *Escherichia coli*
- *Klebsiella pneumoniae*
- *Neisseria gonorrhoeae*
- *Salmonella* spp.
- *Shigella* spp.
- *Staphylococcus aureus*
- *Streptococcus pneumoniae*

These pathogens cause worldwide common hospital and community acquired infections. Rates of antibiotic resistance are reported to be increasing, to the point that infections caused by these pathogens might need to be treated with last resort drugs, which might not only be less effective and safe, but also more resource consuming and not widely available, particularly in low-resource settings. For this reason, AMR in these pathogens is now considered to rank among the most important threats to public health globally. The selected pathogens are also included in the WHO global Priority Pathogens List for research and development to address antibiotic-resistant bacteria, issued in February 2017 [29]. Each country can choose to report on the number of GLASS pathogens according to their own priorities.

### 2.2.3 GLASS methodology

GLASS collects the following information on yearly basis:

1. Information of the status of national surveillance systems gathered through a questionnaire survey.
2. AMR data collected through a case-finding surveillance system, based on specimens sent routinely to laboratories for clinical purposes.
3. Patient and population data collected from national surveillance sites to monitor AMR in different risk groups.

Data on bacterial resistance in human infections are obtained from blood, urine, stool, urethral samples, and cervical swabs. (Table 2.1):

**Table 2.1 GLASS priority specimens and selected pathogens**

| Specimen | Laboratory case definition | Surveillance type and sampling setting | Selected pathogens for surveillance |
|---|---|---|---|
| **Blood** | Isolation of pathogen from blood [a] | Selected sites or national coverage<br>Continuous<br>Patients in hospitals and the community | *Acinetobacter* spp.<br>*E. coli*<br>*K. pneumoniae*<br>*Salmonella* spp.<br>*S. aureus*<br>*S. pneumoniae* |
| **Urine** | Significant growth in urine specimen [b] | Selected sites or national coverage<br>Continuous<br>Patients in hospitals and the community | *E. coli*<br>*K. pneumoniae* |
| **Stool** | Isolation of *Salmonella* spp.[c] or *Shigella* spp. from stool | Selected sites or national coverage<br>Continuous<br>Patients in hospitals and the community | *Salmonella* spp.<br>*Shigella* spp. |
| **Urethral and cervical swabs** | Isolation of *N. gonorrhoeae* from urethral and cervical swabs | Selected sites or national coverage<br>Continuous<br>Patients in hospitals and the community | *N. gonorrhoeae* |

a. Any pathogen isolated from a blood culture may be significant for surveillance locally and nationally; only the prioritised pathogens for global surveillance are listed here.
b. Culture according to local laboratory practice. Catheter samples should be excluded if possible.
c. Diarrhoeal surveillance is for non-typhoid salmonella species; for local clinical purposes, typhoid and paratyphoid should be included.

Currently GLASS accepts both isolate-based and sample-based types of AMR surveillance data, including information on epidemiological variables such as age, gender and origin of infection in tested patients (GLASS Manual for Early Implementation [26]). The isolate-based approach includes the information of number of isolates tested and the proportion of resistant bacteria among the tested isolates. In addition to the collection of data on microbiological isolates the sample-based approach involves the collection of data on all samples taken for microbiological testing and includes information on the number of positive samples for a specific specimen type (both isolates of the target pathogens and other bacteria) as well as number of negative (no microbial growth) samples. This allows, after removal of duplicate results, and assuming that routine microbiological testing is applied systematically, to use the resulting number of tested patients as a proxy for a number of patients with new cases of targeted infection types. Table 2.2 summarises the data collected by GLASS surveillance.

**Table 2.2 AMR data collection for GLASS**

| Type of data collected | AMR Surveillance Approach | |
|---|---|---|
| | Isolate-based | Sample-based |
| Number of patient samples positive for the bacterial pathogens under surveillance | ✓ | ✓ |
| Number of positive patient samples with susceptibility testing results for the bacterial pathogens under surveillance | ✓ | ✓ |
| Numbers of patients with growth and no growth of the bacterial pathogens under surveillance (tested patients) | ✖ | ✓ |

For each pathogen, a number of antibiotic combinations are identified (Annex II). The antimicrobials to monitor were selected because either they are commonly recommended first-line treatments, or resistance in the pathogen–antibiotic combination is of particular clinical and public health concern. This may be due to limited treatment options resulting from increased development of resistance for a specific class of antimicrobials, or limited access to effective drugs. Priorities for countries and regions also vary. As GLASS evolves, specimens to be collected, pathogens to be surveyed, and types of resistance reported will be updated as necessary.

#### 2.2.3.1 Comparative advantages of sample-based surveillance versus isolate-based surveillance

Although both isolate-based and sample-based data can be reported to GLASS, GLASS encourages countries to collect and report sample-based data. The benefits of moving from isolate-based to sample-based surveillance are multiple. Isolate-based surveillance only provides data on resistance patterns within the bacterial population, while sample-based surveillance can provide both basic insight into patterns and the extent of AMR in the tested populations. For example, using as denominator the tested population allows detecting the most frequent type of resistant infections within that population and it allows stratification to identify AMR patterns, e.g. the most affected age-groups and gender, or the most frequent types of antibiotic-resistant infections in communities or hospitals. For countries that provided sample-based data[2] during this data call, different metrics could be generated (see section 3.3 Country Profiles and GLASS Manual for Early Implementation [26]), as the incidence of monitored infections in the tested population, and the incidence of non-susceptible infections stratified by patients characteristics (as age, gender, community versus hospital-acquired infections). In this case, the tested population was defined as the total number of symptomatic patients that sought medical care and from which clinical samples where taken.

Both isolate-based and sample-based surveillance have limitations that should be taken into consideration for cautious interpretation of results. Although infections due to antibiotic-resistant bacteria do not usually present differently from those due to the same but susceptible bacteria, in settings where samples are not routinely sent for microbiological investigation, those examined are more likely to be taken from severely ill patients who have failed first-line and perhaps second-line treatment, and so are more likely to contain resistant strains. Moreover, it is not possible to detect cases from patients that are not seeking treatment or patients that are seeking treatment but that are not tested.

Moreover, limitations of routine surveillance might also create a case for the future development of AMR case-based syndromic surveillance, combined with inventory studies (i.e. a survey to quantify the level of underreporting of detected AMR cases) and capture–recapture methods to validate surveillance data and estimate the frequency of AMR in the population. In addition, the quality of collected data can be improved by diagnostic stewardship (GLASS Diagnostic stewardship - A guide to implementation in antimicrobial resistance [30]). As the purpose of diagnostic stewardship is to encourage and optimise the use of microbiological tests to guide clinical treatment, this will favour more precise data on AMR dynamics and offer valuable guidance for practitioners' to inform therapeutic decisions, even when diagnostic capability is limited (GLASS Manual for Early Implementation [26]).

Despite these limitations, if core epidemiological data are collected on patients and the population from which they derive, and if duplicated results for the same patient are removed, data from surveillance based on routinely collected clinical samples can be used for several purposes:

- Stratification according to specimen type (as a proxy for infection in the respective anatomical site) makes possible to start differentiating problems in different clinical conditions.
- A combination of epidemiological and laboratory data allows stratification of populations for ascertaining the type of infection and where most AMR infections are occurring.
- The extent of AMR infections can be assessed with caution from epidemiological indicators, such as frequency in the tested population and propensity of sampling.
- Information on the geographical spread of priority pathogens and phenotypes in the country and identification of community and healthcare-associated outbreaks can be identified if geographical location is provided.
- If the sampling behavior is stable, routine data from antibiograms can be analysed for new trends by comparing them with data from the previous year, to determine any significant change in important resistant bacteria.
- Prospective and retrospective information on emerging public health threats can be generated.
- Evaluation and optimization of national standard treatment guidelines can be informed.

[2] Latvia, Finland, Republic of Korea, South Africa, and Thailand

### 2.2.4 GLASS data collection and reporting at country level

At country level, samples for culture and AST from patients with suspected infection are sent by clinicians working at participating health-care facilities to local clinical laboratories serving the surveillance sites. Participating surveillance sites enter data into data management software or paper forms, and submit them to the NCC on a regular base, as defined in the national AMR surveillance system protocol. At NCC level surveillance data submitted by the surveillance site are collated and aggregated in GLASS format (GLASS Guide to preparing aggregated antimicrobial resistance data files [31]).

Countries are requested to report data to GLASS once a year. During the data call, NFPs are required to submit to the GLASS-IT platform aggregated AMR data for the previous year and the information of the status of their surveillance system. GLASS secretariat and WHO Regional Offices and Country Offices offer direct support to countries to prepare the aggregated AMR data files and upload them in the GLASS IT platform.

GLASS is also working closely with the European networks, CAESAR and EARS-Net, to facilitate data sharing and avoid "double reporting" (Section 4.2.4.1). This year, four CAESAR countries enrolled in GLASS submitted data on AMR in pathogens from blood via the WHO Regional office for Europe, and through the support of the WHO Collaborating Centres at the Dutch National Institute for Public Health and the Environment. The specially developed CAESAR module in the GLASS IT platform allows export of CAESAR data into the GLASS aggregated database. EARS-Net countries submitted their data to the European Centre for Disease Prevention and Control (ECDC), which has the prerogative of transferring the data to GLASS when indicated by countries. For this first report, the 2016 data from most EARS-Net countries could not be made available in time for inclusion in the GLASS report, except for several countries that chose to report all data to GLASS directly from national level. ECDC and WHO are collaborating to adjust the processes and align the timelines for future data calls.

### 2.2.5 GLASS IT tools

The GLASS IT platform (available at https://extranet.who.int/glass/portal/) is a web-based platform that permits access to all GLASS databases with unique authentication and rights management processes. Currently, the platform hosts four modules/databases:

- AMR data on selected bacteria, aggregated at national level
- AMR data from CAESAR countries (Section 4.2.4.1)

The portal works as a secure web-interface database and allows for submission of aggregated and individual data, population data, as well as surveillance systems implementation data. The platform accepts data in a number of formats, allowing for flexibility and tailored approaches to the needs of individual countries. NFPs are provided with a user name and a password, and are able to upload, review, and submit new data, view their upload history, access and download previously submitted data, and generate and view customised reports. Moreover, WHONET, a database software developed for the management and analysis of microbiology laboratory data with a special focus on the analysis of antimicrobial susceptibility test results, now has a new feature, which allows exporting directly to the GLASS data structure [32].

NFPs can also use the platform to display global statistics and dashboards based on the data provided. Although all databases have a common data workflow (enrolment, data upload, data validation, import, and report publication), specific statistics on data provided at the portal level can be produced.

### 2.2.6 New modules for GLASS

Various new modules are now being incorporated into GLASS, which will facilitate the alignment of AMR data from infections of selected pathogens with other AMR related data. The new modules will enable a more comprehensive, standardised, and detailed data collection that might facilitate a better understanding of complex AMR dynamics. The new modules currently under development:

- Monitoring of antimicrobial consumption (Section 4.5)
- Special project on AMR for Gonorrhoea (enhanced GASP) (Section 4.3)
- One Health integrated surveillance on Extended Spectrum Beta-Lactamase (ESBL)-producing *E. coli*. (Section 4.4)

Other modules are expected within the early implementation phase.


SECTION
03

# GLASS first data call

## 3.1 Reader's guide to GLASS results

### 3.1.1 Data validity

A sound methodology is required to monitor reliable and harmonised data and report a valid estimate of global antimicrobial susceptibility in a common set of bacterial pathogens. While the methods currently applied in GLASS have been internationally approved, surveillance is a complex function [33]. Many different healthcare and public health professionals are involved in the many steps of the data generation process, requiring commitment and training at different levels to ensure high-quality data. The diversity in countries' levels of capability and resources and other limiting conditions outside the direct control of the national AMR surveillance system affects data collection and validity.

GLASS first data call was opened between April and July 2017. As this was the first year of GLASS data collection, great variability was expected in the completeness and quality of AMR data submitted, and differences were addressed in order to promote a harmonised representation of the results and to show country efforts. For this reason, comparison of AMR results between countries or regions was not attempted in order to avoid misrepresentations of the epidemiological status of global resistance.

### 3.1.2 Data analysis and interpretation

#### 3.1.2.1 Information on status of national AMR surveillance system

To get a clear overview of the countries AMR surveillance system status, GLASS AMR NFPs were asked to complete a short questionnaire to report on implementation of the core components of the national AMR surveillance activities (GLASS Manual for Early Implementation [26]), and progresses being made. The questionnaire covers three main areas: (1) overall coordination; (2) surveillance system; and (3) quality assurance and standards (GLASS Implementation Questionnaire [34]).

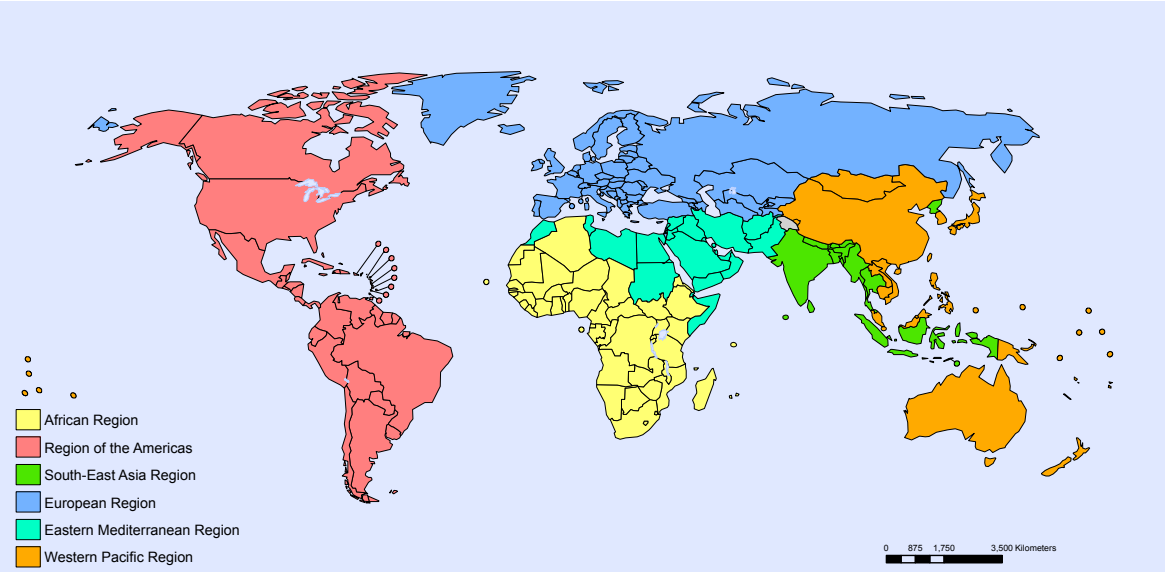
Each area consists of a set of indicators developed to measure the development and strengthening of national surveillance of AMR (Table 3.1). The indicators are monitored on a yearly basis to assess countries' progress.

**Table 3.1 GLASS country surveillance implementation indicators**

| AREA | INDICATOR | OUTCOMES |
|---|---|---|
| Coordination | National Coordination Centre (NCC) has been set up | Yes/No/Not known |
| | National focal point (NFP) appointed | Yes/No/Not known |
| | National AMR surveillance plan developed | Yes with budget/Yes without budget/No/Not known |
| | Country AMR surveillance standards and guidelines incorporate GLASS methodology | Yes/No/Not known |
| | National reference laboratories (NRL) designated | Yes/No/Not known |
| Surveillance system | Total number of AMR surveillance sites contributing to the national surveillance system | Numerical |
| | Number of local clinical laboratories performing AST that support the national AMR surveillance sites | Numerical |
| | Number of national AMR surveillance sites providing data to GLASS in the reporting period | Numerical |
| Quality Assurance (QA) | External Quality assurance (EQA) is provided for NRL | Yes/No/Not known |
| | EQA is performed for laboratory participating in GLASS | Yes/No/Not known |
| | EQA is covering bacterial identification and AST | Yes/No/Not known |
| | Pathogens included in GLASS are covered by EQA | Yes/Some/None/Not Known |
| | Type of AST standards followed | CLSI/EUCAST/Other |

Countries implementation indicators, provided by the 1st GLASS data call, are summarised in Section 3.2 by WHO region (Fig 3.1): African Region (AFR), Region of the Americas (AMR/PAHO), Eastern Mediterranean Region (EMR), European Region (EUR), South-East Asia Region (SEAR), and Western Pacific Region (WPR). Individual country implementation results are further presented as infographics in country profiles (Section 3.3).

**Figure 3.1 WHO Regions**




### 3.1.2.2 GLASS AMR data

#### 3.1.2.2.1 Reported Data

GLASS requires submission of two types of AMR data files generated from the same source database (GLASS guide to preparing aggregated AMR data files [31]).

1. The resistant, intermediate, susceptible "RIS" file with susceptibility testing results. This is data (aggregated from all participating national surveillance sites submissions) on the number of patients with positive cultures per specimen type and AST results for each GLASS pathogen–antibiotic combination, interpreted according to EUCAST [35], CLSI [36] or other national definitions. Data includes numbers of patients with susceptible, non-susceptible, intermediate, and resistant isolates, as well as numbers of isolates with unknown susceptibility. Two different type of unknown result are recorded: "Unknown_no_AST" representing the number of isolates with AST results not reported (or not performed) for a specific antibiotic, and "Unkown_no_breakpoints" representing the number of isolates with AST performed but no interpretation of results available for a specific antibiotic. The AST data is stratified according to core patient variables (GLASS Manual for Early Implementation [26]):
   - Age: age-groups defined as per the WHO Global Health Observatory (less than 1 year, 1-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, over 85 years), unknown [26]
   - Gender: female, male, unknown
   - Infection origin: hospital, community, unknown. Countries were advised to use the following definition: "Hospital" origin is selected for patient admitted for >2 calendar days when the specimen was taken or admitted to the health care facility for <2 calendar days but transferred from another health-care facility where he or she was admitted for ≥2 calendar days. "Community" origin is selected for patients cared for at outpatient clinics or patients in hospital for ≤2 calendar days when the specimen was taken. Specimens collected from hospital patients in hospital on day 3 or later are used as a proxy for hospital-acquired infections, and those collected from patients in the community or in hospital on day 1 and 2 are considered a proxy for community infections. Countries using a different classification method were nevertheless invited to report infection origin data in the GLASS format.

2. SAMPLE file with the numbers of patients seeking care at surveillance sites - in hospital and outpatient clinic facilities - from whom clinical specimens were taken over a defined period, stratified by the same variables as in the RIS file described above.

#### 3.1.2.2.2 Data preparation

GLASS requires input data to be de-duplicated by the country of origin, so that one isolate represents one patient. Thus, when several cultures are collected from one patient, duplicate findings for the same patient are excluded. Only the first isolate per patients, per pathogen, per reporting period, per stratification level is included. This also minimises bias associated with reporting of repeated cultures. Note that for national and local surveillance it is important to collect consecutive isolates of the same pathogen in order to monitor clinical episodes characteristics. De-duplication and data quality assessment should be performed either at surveillance sites before submission to the NCC or by the NCC. If de-duplication is done locally, the NCC should also conduct new checks for duplicates and data quality. Finally, it is the task of the designated NFP to upload the datasets including aggregated data at national level onto the GLASS IT platform (GLASS guide to uploading aggregated AMR data) [37] GLASS data management team offers direct support to countries both for de-duplication and aggregation of the data, and quality checks are run during the data validation process.

GLASS requires countries to include a dataset batch identification number - for example "Data set 1", "Data set 2" - in order to distinguish sub-sets of national aggregated data. This is used when countries are not able to aggregate national data in a single data set, or when dividing the national data set has an important added value, (GLASS guide to preparing aggregated AMR data files [31]).

#### 3.1.2.2.3 AMR data validation and analysis

Countries are responsible for ensuring the validity, the consistency, and the completeness of AMR data submitted to GLASS. A second validation steps is performed during the AMR uploading process thanks to a series of automatic checks built-in the GLASS platform, which identify issues related to the integrity of the dataset (i.e., variables, codes) and the consistency of the data provided (i.e., specimen-pathogen-antibiotic combinations and validity of the AST results provided). Summary tables are also generated allowing the NFP to verify that the uploaded data reflects what was prepared. Data uploading can be finalised only after all the validation steps are completed. Once uploaded, the last validation step is performed by the GLASS team. Data are exported into STATA 14 (StataCorp LP, Texas, USA) and summarised to identify unexpected distribution of age, gender, infection origin, and AST results for each specimen-pathogen-antibacterial combination. Communication with countries is maintained during this stage in order to resolve possible data issues or clarify existing gaps in data submission. In case of errors, countries are asked to correct and resubmit their data. Validated data are then analysed using STATA 14 software and the R Software [38].

For each country, a dashboard is produced and included in the country profile (Section 3.3) to indicate range of completeness of data submitted for each variable: specimens, selected pathogens, gender, age, infection origin. An overview table is created with the overall RIS and SAMPLE data file submissions, showing numbers of tested patients per specimen type and numbers of patients with growth of GLASS pathogens, stratified per infection origin.

AMR data is summarised by country, and main results represented graphically and compiled into tables (Section 3.3 and the report electronic supplementary material [http://www.who.int/glass/resources/publications/early-implementation-report/en/]). AST results are categorised as follow: susceptible, non-susceptible (non-susceptible + intermediate + resistant), and unknown (unknown_no_AST + unkown_no_breakpoints).

Data is described using the following approaches (GLASS Manual for Early Implementation [26]):

1. For each specimen type, pathogen, and antibiotic under surveillance, the proportions of patients with growth of non-susceptible strains are calculated using the following formula and presented graphically:

$$\frac{\textit{Number of patients with growth of non-susceptible strains of bacteria species under surveillance (per specimen type and antibiotic)}}{\textit{Total Number of patients with growth of bacteria species under surveillance (per specimen type and antibiotic)}}$$

AMR rates are not shown for pathogen-antibiotic combinations that are not reported and/or that have less than ten AST results and/or have 100% unknown AST results. In some case, countries have asked to remove antibiotics in order to avoid overestimation due to selective testing. In the graphs, bars are not colour-filled if AST unknown results are more than 30%

Proportion confidence intervals (CIs) are calculated using Wilson method, to address limitations due to small sample sizes or zero values [39]. Overall AST results, proportion of samples with unknown AST and stratified AST results by specimen type, gender, infection origin, and age are provided in the electronic supplementary material [http://www.who.int/glass/resources/publications/early-implementation-report/en/]).

For countries that submitted sample-based data[1] further analysis is performed. It is important to note that as countries were asked to provide only clinically significant results, positive cultures reported are considered as a proxy of infection. In addition, data deduplication only allowes new cases to be reported. Thus, incidence of infection with pathogens under surveillance and incidence of infection with pathogens non-susceptible to specific antibiotics are calculated for the tested population, defined as the total number of symptomatic patients that sought medical care and from which samples of different specimen types where taken.

2. For each specimen type, infection origin and pathogen, rates of patients with new infections are calculated per 100,000 tested patients using the following formula and presented graphically:

$$\frac{\textit{New cases of infection in the population tested during reporting period (per specimen type, pathogen, and infection origin)}}{\textit{Population tested during the reporting period (per specimen type and infection origin)}}$$

Subsequently, for each specimen type, infection origin, pathogen, and antibiotic under surveillance, rates of patients with new growth of non-susceptible strains, are calculated per 100,000 tested patients, using the following formula and presented graphically:

$$\frac{\textit{New cases of AMR in the population tested during reporting period (per specimen type, pathogen, infection origin and antibiotic)}}{\textit{Population tested during the reporting period (per specimen type and infection origin)}}$$

The two charts are presented aligned to show the relationship between the magnitude of each pathogen contribution to infection in a specific anatomical site and the frequency of infections caused by pathogens resistant to specific antibiotics.

3. Pathogen combination with meropenem is chosen to illustrate resistance to carbapenems. As indicated by EUCAST, meropenem offers the best compromise between sensitivity and specificity in terms of detecting carbapenemase-producers. Carbapenem resistance is one of the most disturbing types of resistance recognized worldwide, with several carbapenem-resistant pathogens included as critical priority in the WHO global Priority Pathogens List [29]. When meropenem is not tested, susceptibility to imipenem results are shown.

   For each specimen type, pathogen, and infection origin, incidence of carbapenems non-susceptible strains are calculated per 100,000 tested patients, stratified by gender and age using the following formula, and presented graphically

$$\frac{\textit{New cases of AMR due to carbapenem non-susceptible strains in the tested population during reporting period (per specimen type, pathogen, infection origin, age, and gender)}}{\textit{Tested population during the reporting period (per specimen type, infection origin, age, and gender)}}$$

In all incidence graphs AMR rates are not shown for pathogen-antibiotic combinations that are not reported and/or that have less than ten AST results and/or have 100% unknown AST results. If proportion of unknown AST result is more than 30% only the antibiotics names are shown, without any graphical representation of the outcomes. If the proportion of provided information on infection origin is below 70%, results are not stratified. Incidence CIs are calculated using Wilson method, to address limitations due to small sample sizes or zero values [39]. Results stratified by gender, infection origin, and age for all reported antibiotics are provided in the report electronic supplementary material [http://www.who.int/glass/resources/publications/early-implementation-report/en/]).

### 3.1.3 Limitations in interpretation of results

Limitations of any research or surveillance system are those characteristics linked with the design or methodology that impact or influence the interpretation of the findings from the data collected. They are a by-product of the ways in which surveillance systems are initially designed and a direct consequence of all the constrains involved in health data collection (country policies and agendas, challenging logistic, lack of resources, sampling bias, poor diagnostic capacity, measurements errors, issues with data management, etc.). While interpreting GLASS results, it is paramount to identify limitations of the methodology in order to assess to which extent the outcomes are a true reflection of the status of surveillance systems reported by enrolled countries and their AMR epidemiological profiles, and to inform future development. The following limitations have been identified:

[1] Latvia, Finland, Republic of Korea, South Africa, and Thailand

- Data aggregation is a serious limitation. In this first round of data analysis, no statistical analysis could be performed to test for association among infection types and the proportion of resistance for a specific pathogen, or to identify risk factors linked with age, gender, or infection origin. Furthermore, it was not possible to group antibiotics in classes to identify trends, because AST results could not be segmented by patient, resulting in overestimation of resistance when merging outcomes from different antibiotics. Aggregation of data also considerably limits options for data validation and epidemiological characterisation - e.g., making the detection and subsequent validation of data from countries with unusual antimicrobial patterns impossible to do. The inclusion of aggregated data at national level was suggested by country representatives at the 1st High Level Technical Meeting on Surveillance of Antimicrobial Resistance for Local and Global Action in Stockholm in 2014 [33]. Although not perfect, aggregated data still offer a valuable set of information regarding the proportion and frequency of AMR within a given population, and once the limitations to its use are understood, it can produce meaningful insight into the development of resistance in countries.
- A small set of progress indicators (Table 3.1) was used to evaluate the implementation of countries surveillance systems in this first round of data call. In addition, information is produced by countries through self-assessment, and a methodology to define the magnitude and validity of reported data based on the functionality of those systems, is still not in place. However, the information collected in this round allowed for a first overview of country activities and provided the baseline knowledge for further development of support.
- The number of surveillance sites in each country can vary depending on the existing national surveillance system structure, and both financial and technical capability. In addition, the extension of the country territory and its geographical boundaries has an impact on the set up of the sites. However, the data are presented together, without any weighting, in order to provide an overview of the current status of national surveillance systems and to identify gaps for future implementation.
- Lack of a sampling strategy generates selection bias that may affect the representativeness and interpretation of results and does not allow inference to country representativeness.
- Case-finding is done only on the population of patients that seeks medical care and is tested. For this reason incidence can only be calculated for this population.
- Most information is still generated at laboratory level, and lacks epidemiological insight.
- Some of the isolates identified may possibly represent cases of contamination or colonisation. However, as the data are aggregated, it is countries' responsibility to assess the clinical significance of positive cultures. Therefore, positive cultures reported are considered a proxy of infection.
- There are discrepancies in reporting negative results and "not tested" antibiotics. Although countries have the options to select "no AST" or "unknown breakpoints" for unknown AST results, if certain pathogen-combinations are not reported in the RIS file, it is not always possible to know whether there are no isolates of the organism identified or whether isolates are indeed identified but not tested for antimicrobial susceptibility. In addition, when data show high percentage of unknown AST results for specific antibiotics, the level of uncertainty on the AMR rates generated can be very high. Therefore, for this report a 30% unknown AST results cut-off value was chosen to graphically represent different outcomes [41]. This value was selected as giving a reasonable balance in terms of results inclusion and proportion of isolates with data available [42]. To avoid this, going forward, countries should compile a list of the routinely antibiotic tested for each pathogen in each specimen, and always report negative results.
- Data completeness, particularly for population variables – age, gender, and infection origin – could not be assured for all reporting countries. Yet, the effort countries made to send the most complete and reliable data was taken into consideration, and data analysis was adapted to create a set of results that could be harmonised between different data submissions.
- Although the CLSI recommendation is to only show results when a minimum of 30 isolates are reported, this year it was chosen a cut point of 10 isolates to fairly present data from countries with limited resources or very young surveillance systems [40].

# 3.2 Results

## 3.2.1 Information on status of national AMR surveillance system

40 (95.2%) of 42 countries enrolled in GLASS provided information on the status of the national surveillance system by the end of the data call. The total number of countries per WHO region, and the number of countries reporting to GLASS this year is shown in the table below (Table 3.2). As described in section 3.1.2.1 the indicators are summarised and compared between regions for the three areas of implementation (coordination, surveillance systems, and quality assurance and standards) and shown in Figure 3.2-5.

**Table 3.2 Number of WHO member countries, per region, and number of countries enrolled in GLASS and who reported in the first data call**

| Region | Number of countries in the region | Number of countries enrolled to GLASS* | Number of countries reporting to GLASS |
|---|---|---|---|
| AFR | 47 | 10 | 9 |
| AMR/PAHO | 35 | 3 | 2 |
| EMR | 21 | 12 | 9 |
| EUR | 53 | 19 | 15 |
| SEAR | 11 | 2 | 1 |
| WPR | 27 | 4 | 4 |

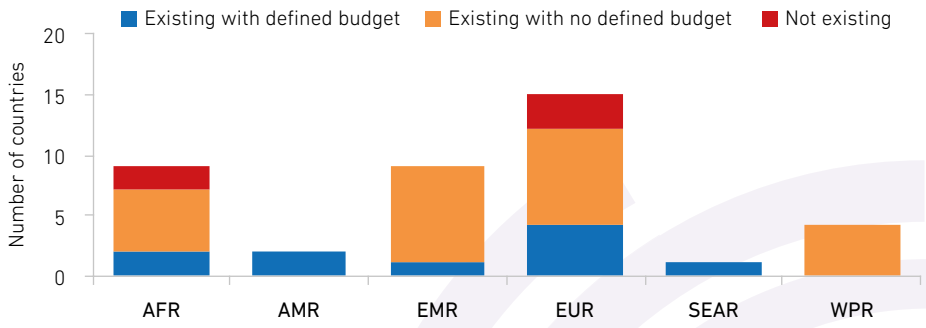
*Numbers enrolled as of 9 December 2017.

In general, all the indicators showed progress for countries enrolled in GLASS in the first 2 years after its launch, particularly on setting up of the NCC, the EQA for testing of GLASS pathogens, and the development of national AMR surveillance plans.

### 3.2.1.1 Coordination

As expected during the initial steps of the establishment of a functional system, almost all coordination elements for AMR surveillance are in place in all enrolled countries. Most reporting countries have AMR national surveillance plans established (Fig 3.2), and some countries have launched their national plans with defined budget, showing growing commitment to the AMR issue.

**Figure 3.2 Functioning national AMR surveillance plan (per WHO regions)**




The core components for effective surveillance suggested by GLASS are present in the majority of the countries in all regions: establishment of a NCC (Fig 3.3), nomination of AMR surveillance NFP (Fig 3.4) and designation of a NRL to support national AMR surveillance (Fig 3.5).

**Fig. 3.3 Establishment of National Coordination Centre (NCC) (per WHO region)**

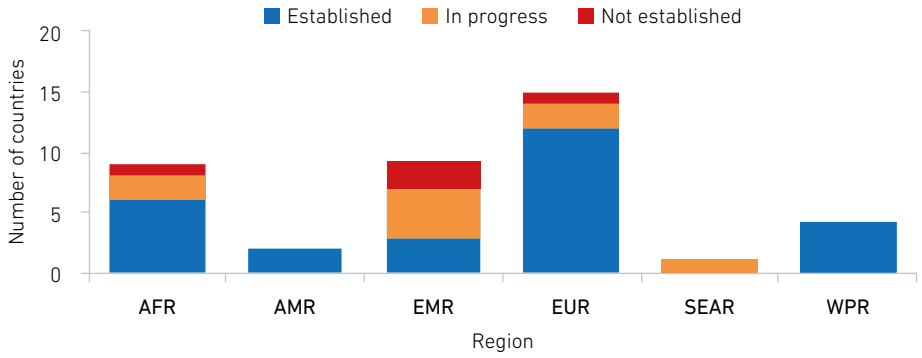



**Fig. 3.4 Nomination of National Focal Point (NFP) (per WHO region)**

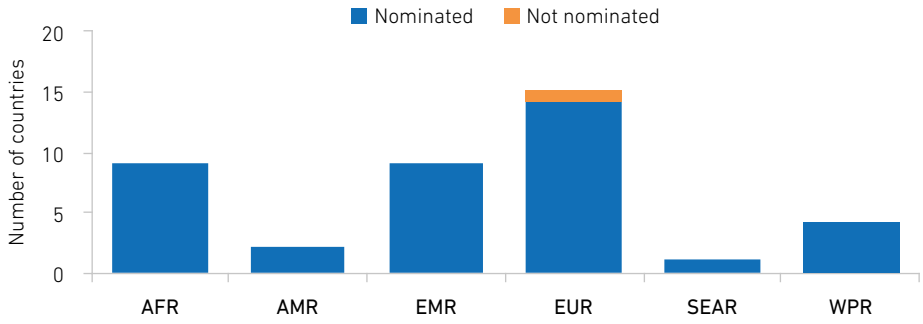
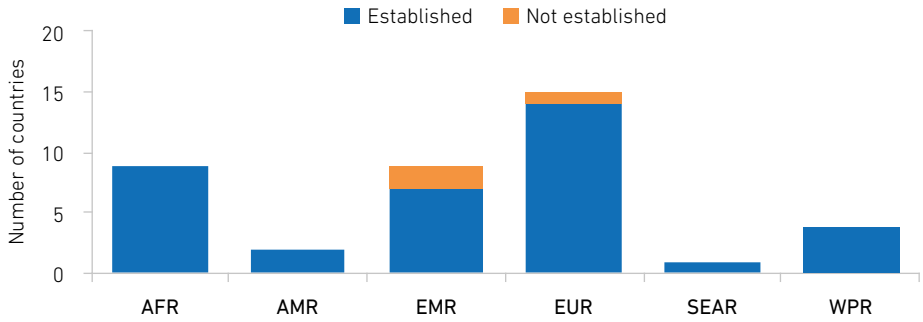



**Fig. 3.5 Establishment of national reference laboratory (NRL) (per WHO region)**




### 3.2.1.2 Surveillance systems

Most enrolled countries have existing national AMR surveillance sites compliant with GLASS methodology, but not all sites based at hospitals and outpatient clinics are yet providing data to GLASS (Fig 3.6 and 3.7).

**Fig. 3.6 Number of national surveillance sites in each country providing data to GLASS: hospital category (per WHO region)**

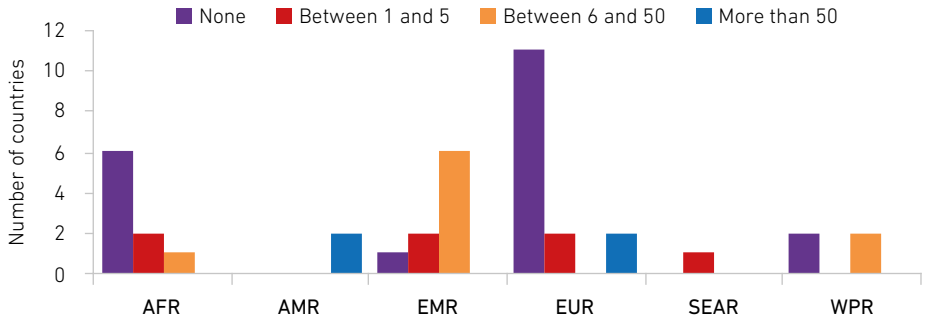
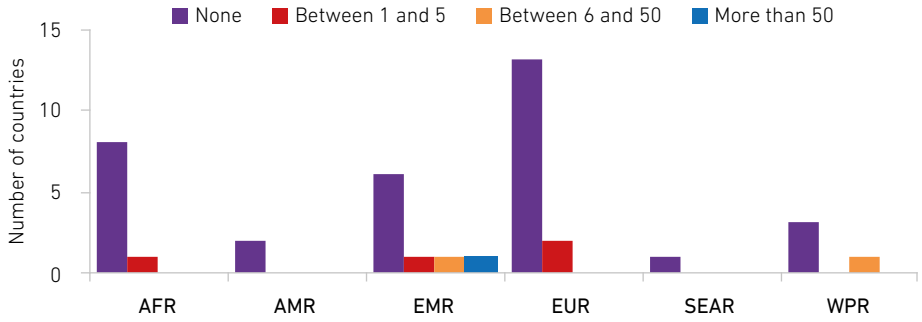
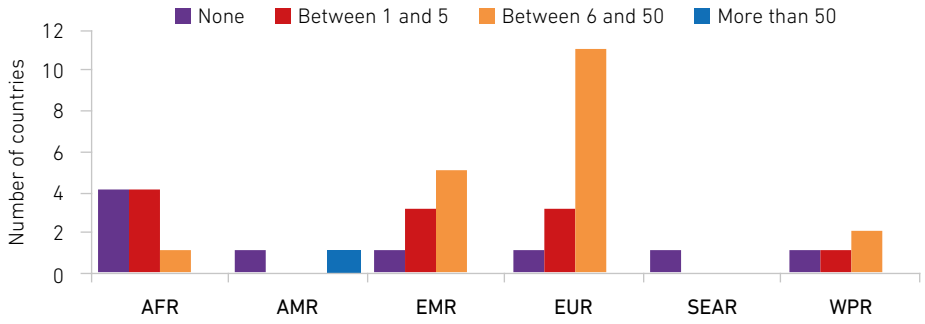


**Fig. 3.7 Number of National surveillance sites in each country providing data to GLASS: outpatient clinic category (per WHO region)**




Most surveillance sites are supported by local clinical laboratories providing AST, but in few countries, the samples are processed centrally at the NRLs (Fig 3.8). In general, there is a small number of outpatient clinics surveillance sites reporting AMR data. Several countries have deployed efforts to provide the infection origin of reported AMR data. The discrimination of possible infections sources could influence antimicrobial prescription and consumptions behaviours.

**Fig. 3.8 Number of local clinical laboratories in each country performing AST to support national AMR surveillance sites (per WHO region)**




Section 3

### 3.2.1.3 Quality assurance and standards

Almost all NRL participate in an EQA scheme (Fig 3.9). However, external quality assurance is still not provided to all local clinical laboratories from the national AMR surveillance programme (Fig 3.10). Bacterial identification and AST are quality controlled in most NRL (Fig. 3.11), but EQA is still not always available for all GLASS pathogens. Figure 3.12 shows GLASS pathogens tested as covered by EQA. All countries reported following standards for AST, with CLSI and EUCAST being the most commonly used (Fig 3.13) [35, 36].

**Figure 3.9 EQA provided to the national reference laboratory (NRL) (per WHO region)**

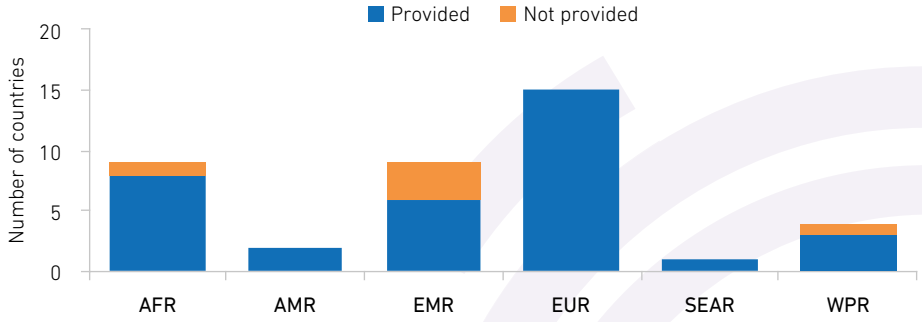


**Fig. 3.10** EQA provided to local laboratories participating in GLASS (per WHO region)

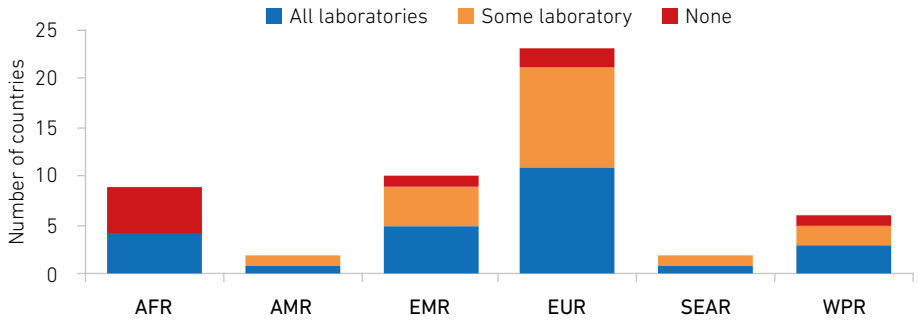



**Fig. 3.11** EQA provided for bacterial identification and AST (per WHO region)

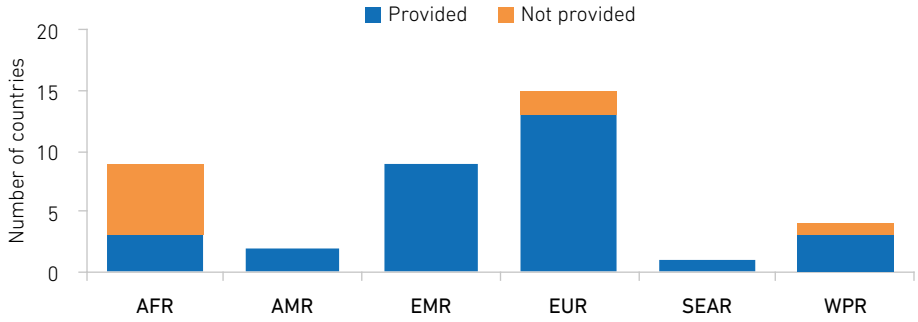



**Fig. 3.12** GLASS pathogens testing covered by EQA (per WHO region)

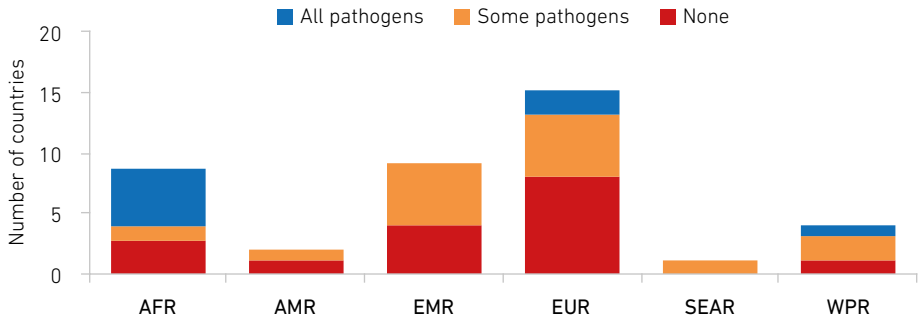
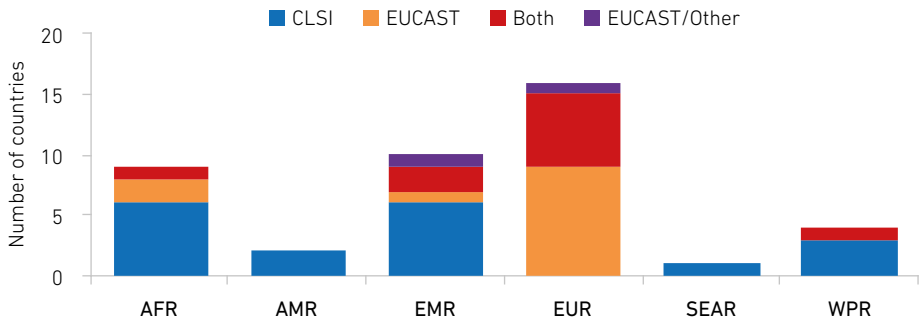



**Fig. 3.13** Types of AST standards followed by countries (per WHO region)



## 3.2.2 Country profiles

### 3.2.2.1 Profiles Structure

The profile contains country information on AMR surveillance implementation and a summary of AMR data. A short narrative describes countries engagement with AMR surveillance. In each country profile, an infographic summarises reported surveillance indicators for the three core components of the national AMR surveillance system.

When AMR data are submitted, a dashboard shows, through a colour-coded system, the proportion of the data submission, and a second table gives an overview of the data reported. For countries that have submitted isolate-based data, AST results are presented in a set of bar charts (referred to as a Pathogen non-susceptibility overview). For countries[2] that have also submitted sample-based data, two more sets of graphics are presented. The first set presents the incidence of infection in different anatomical sites caused by selected pathogens and incidence of infection caused by the pathogens with resistance to specific antibiotics in the tested population. Where data are available, the second set describes specific resistance to carbapenems in different risk-groups (i.e., non-susceptible pathogen – antimicrobial combination incidence and non-susceptible pathogen-carbapenem combination stratified incidence)

In the non-susceptibility overview graphs the denominator used to calculate the proportion of non-susceptibility for each antibiotic can vary based on the number of isolates tested for each antibiotic. CIs allow for a better representation of non-susceptibility according to the different sample sizes. In general, in order to highlight of possible selective testing behaviours, a 30% unknown AST results cut-off rule was applied to the graphical representation of the outcomes [41, 42]. In the pathogen non-susceptibility overview graphs only outcomes with less than 30% unknown AST results are presented with colour-filled bars, while for the others outcomes the bar filling is transparent. In the non-susceptible pathogen – antimicrobial combination incidence graphs, for antimicrobials with more than 30% unknown AST results only the antibiotic name is reported, without any graphical representation. Overall, results are not shown for pathogen-antibiotic combinations with less than 10 AST and/or 100% unknown AST results.

The number of isolates tested for each antibiotic, the proportions of non-susceptible isolates, also stratified for age gender and origin, the proportion of isolates with unknown AST result, and the incidence, also stratified for age, gender and infection origin, of non-susceptibility in the tested population are available in the report supplementary electronic material [http://www.who.int/glass/resources/publications/early-implementation-report/en/].

Country profiles are also published on the WHO Global Health Observatory page for GLASS at http://www.who.int/gho/glass/en/.



[2] Latvia, Finland, Republic of Korea, South Africa, and Thailand

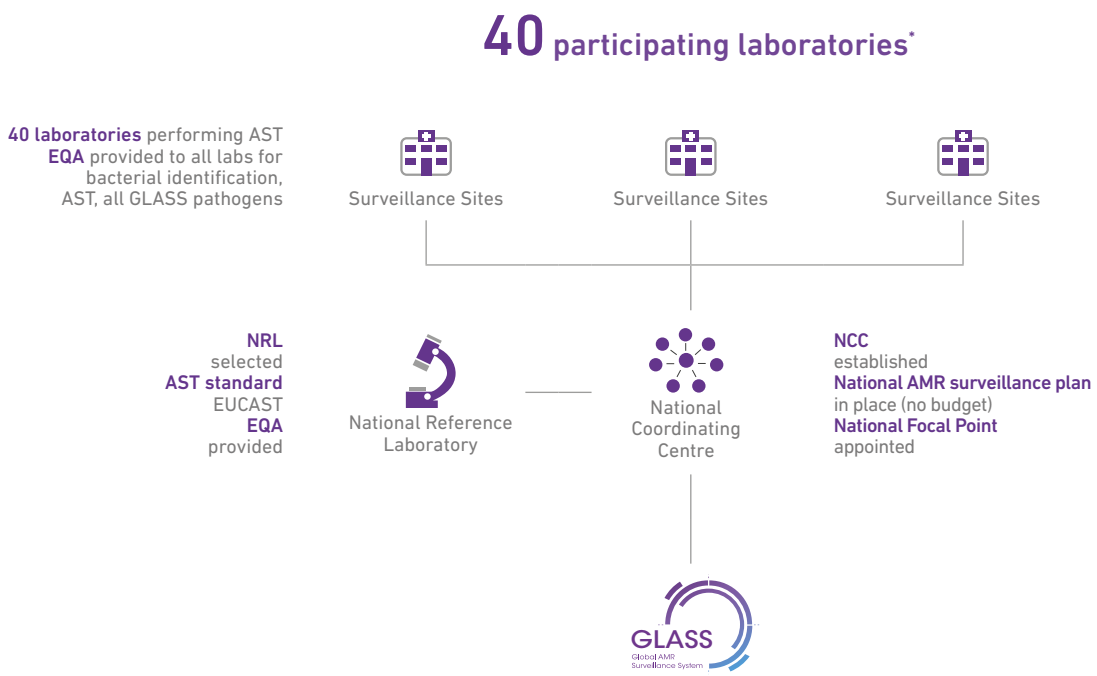
# Country profiles

# Austria

## Population[1] 8.6 million

The AMR surveillance in Austria is coordinated by the Federal Ministry of Health with the annual Austrian report on AMR (AURES) published annually. Austria is implementing the National Action Plan on AMR published in 2014. The country participates in the EARS-NET and has been enrolled in GLASS since June 2016.

## Current status of the national AMR surveillance system




*The identification of the total number of surveillance sites submitting specimens to participating laboratories was not possible due to the set up of the national surveillance system

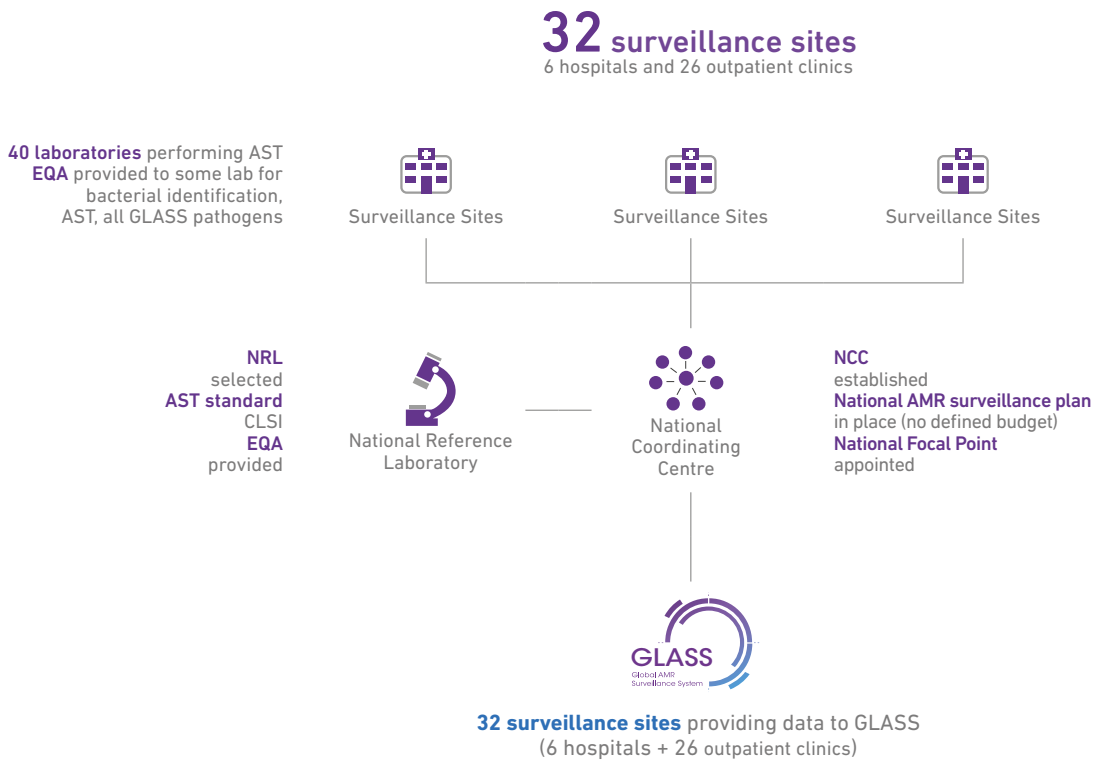
1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Bahrain

## Population[1] 1.37 million

Bahrain has a National Action Plan on AMR that was approved in 2016. The functioning national AMR surveillance system produces regular reports and covers about 80% of the population. Bahrain has been enrolled in GLASS since October 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🔴 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Bahrain

## Population 1.37 million

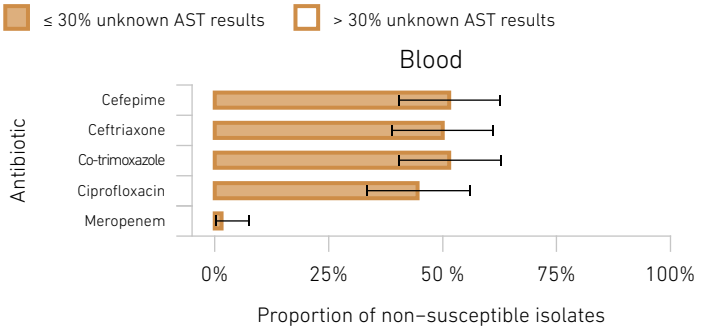
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | - |
| | | | | *E. coli* | - | - | 72 |
| | | | | *K. pneumoniae* | - | - | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | - | - | - |
| | | | | *S. pneumoniae* | - | - | - |
| URINE | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

## Pathogen non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Escherichia Coli***




2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

# Bosnia and Herzegovina

## Population[1] 3.53 million

AMR surveillance activities are conducted by two networks; one in the Federation of Bosnia and Herzegovina and one in Republic Srpska. AMR surveillance covers about two thirds of the population of the Federation of Bosnia and Herzegovina and at least 75% of the population of Republic Srpska. The country participates in CAESAR and has been enrolled in GLASS since September 2016.

A description of the current status of the Republic of Srpska and the Federation of Bosnia and Herzegovina surveillance systems can be found in the CAESAR annual report 2017 [50] and will be made available on the WHO GLASS website (http://who.int/glass/en/).

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *E. coli* | 🟢 | 🟠 | 🟢 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟢 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *S. aureus* | 🟢 | 🟢 | 🟠 | 🔴 |
| | | *S. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟠 |
| URINE | 🟢 | *E. coli* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟢 |
| STOOL | 🟢 | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *Shigella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| GENITAL | 🟢 | *N. gonorrhoeae* | 🟢 | 🟢 | 🟢 | 🟢 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | 2 | 30 | 126 |
| | | | | *E. coli* | 41 | 20 | 159 |
| | | | | *K. pneumoniae* | 12 | 26 | 116 |
| | | | | *Salmonella* spp. | - | - | 7 |
| | | | | *S. aureus* | 25 | 15 | 140 |
| | | | | *S. pneumoniae* | 8 | 1 | 13 |
| URINE | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

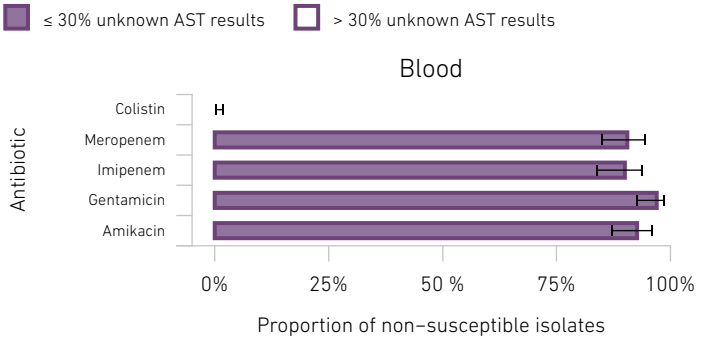
# Bosnia and Herzegovina

## Population 3.53 million

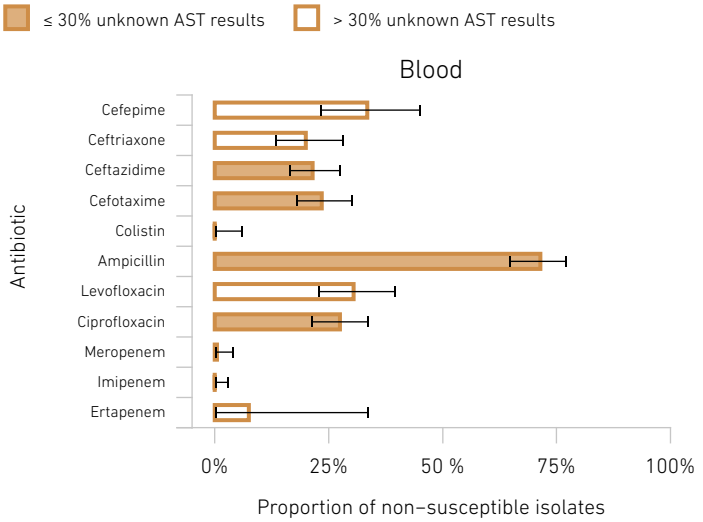
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

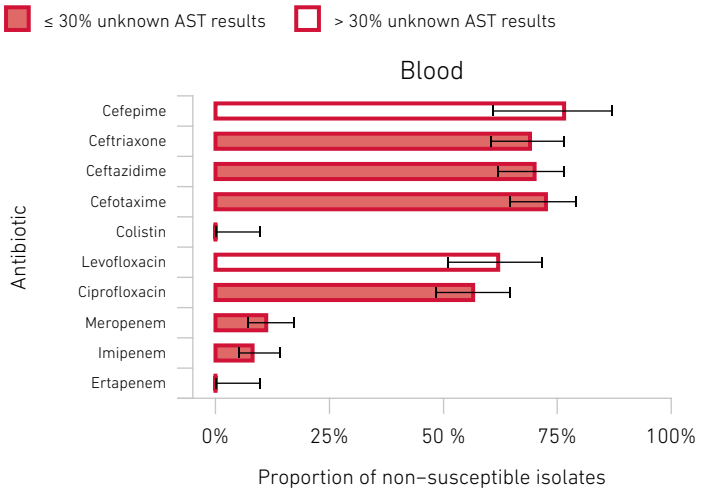
***Acinetobacter* spp.**




***Escherichia coli***




***Klebsiella pneumoniae***

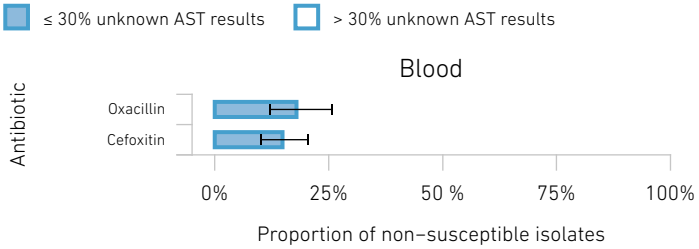



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

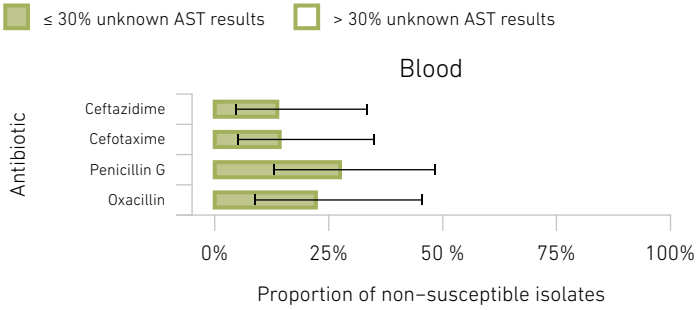
# Bosnia and Herzegovina

## Population 3.53 million

***Staphylococcus aureus***




***Streptococcus pneumoniae***

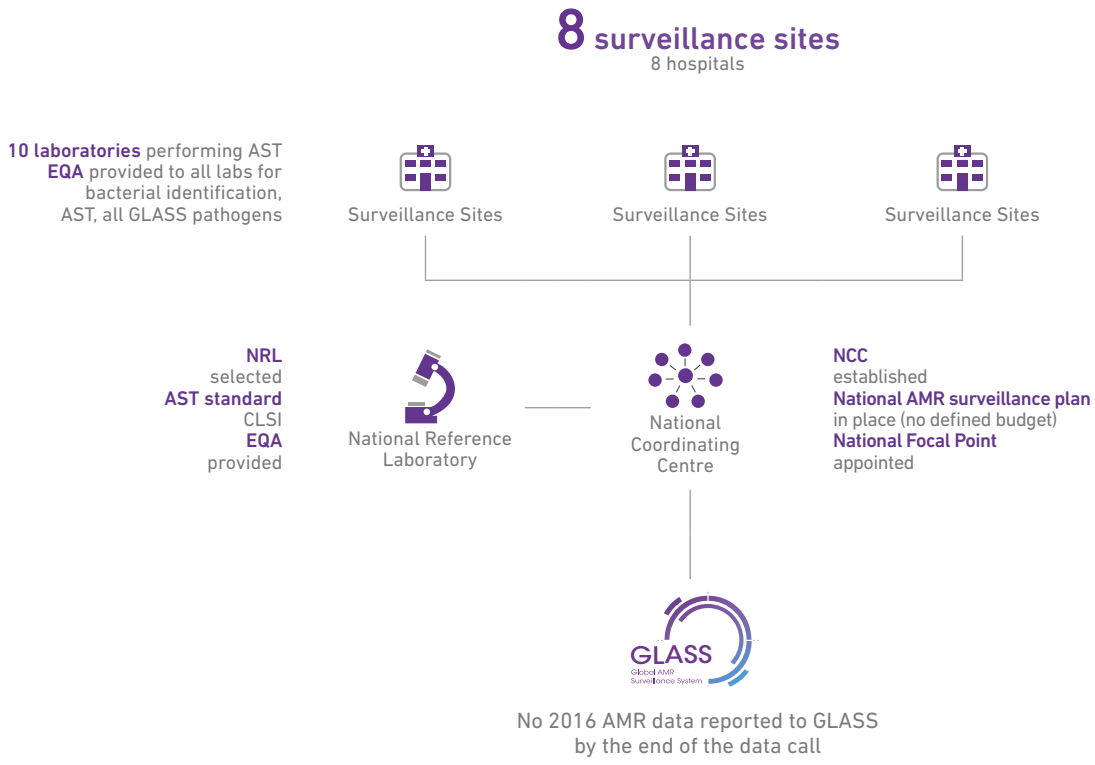


# Cambodia

## Population[1] 15.51 million

Cambodia has approved its National Action Plan on AMR and is building its national AMR surveillance system. The country has been enrolled in GLASS since April 2016.

## Current status of the national AMR surveillance system



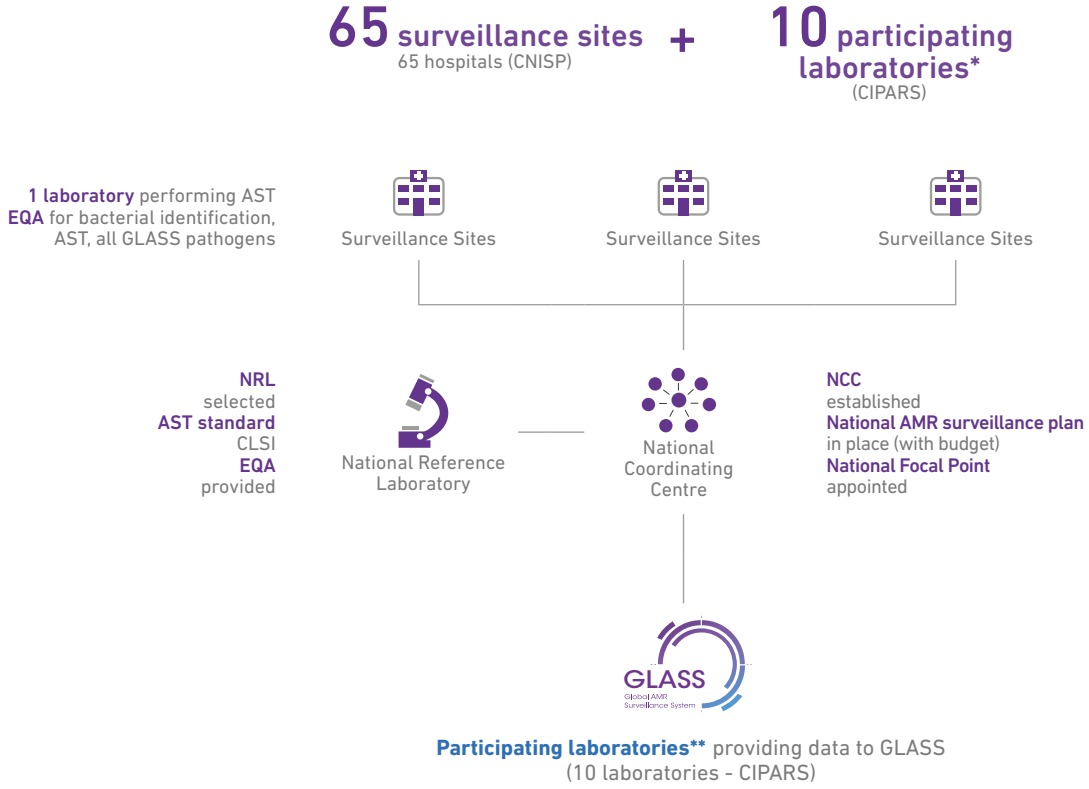

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Canada

## Population[1] 35.95 million

The Canadian Antimicrobial Resistance Surveillance System (CARSS) integrates surveillance data from laboratory reference services and nine surveillance systems operated by the Public Health Agency of Canada including the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) which monitors antimicrobial resistance in enteric bacteria along the food chain from animals to humans as well as antimicrobial use in animals, and the Canadian Nosocomial Infection Surveillance Program (CNISP), which monitors nosocomial and antimicrobial resistant infections in tertiary-care hospitals. The Federal Action Plan on Antimicrobial Resistance and Use in Canada was published in 2015, and Canada enrolled in GLASS in November 2016.

## Current status of the national AMR surveillance system




* For CNISP and CIPARS all AST testing is done at a central lab (National Microbiology Laboratory) – the participating labs provide the isolates and the epi data

** The identification of the total number of surveillance sites submitting specimens to participating laboratories was not possible due to the set-up of the National surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🟠 | 🟢 | 🔴 |
| | | *S. aureus* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🟠 | 🟢 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🔴 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Canada

## Population 35.95 million

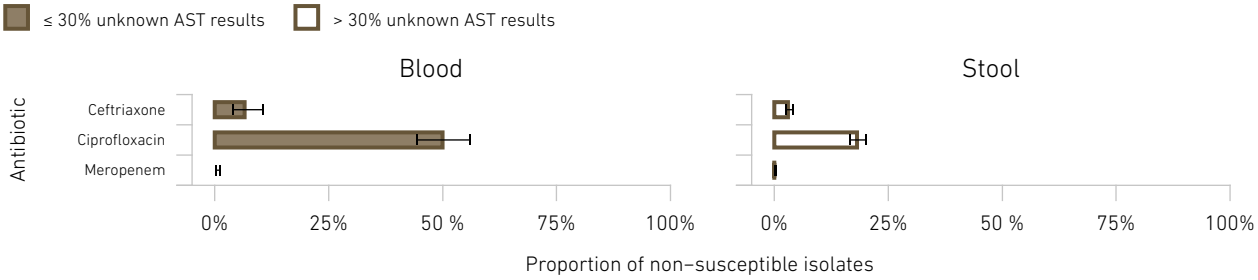
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | - |
| | | | | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| | | | | *Salmonella* spp. | - | - | 357 |
| | | | | *S. aureus* | - | - | - |
| | | | | *S. pneumoniae* | - | - | - |
| URINE | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | 3 370 |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Salmonella* spp.**



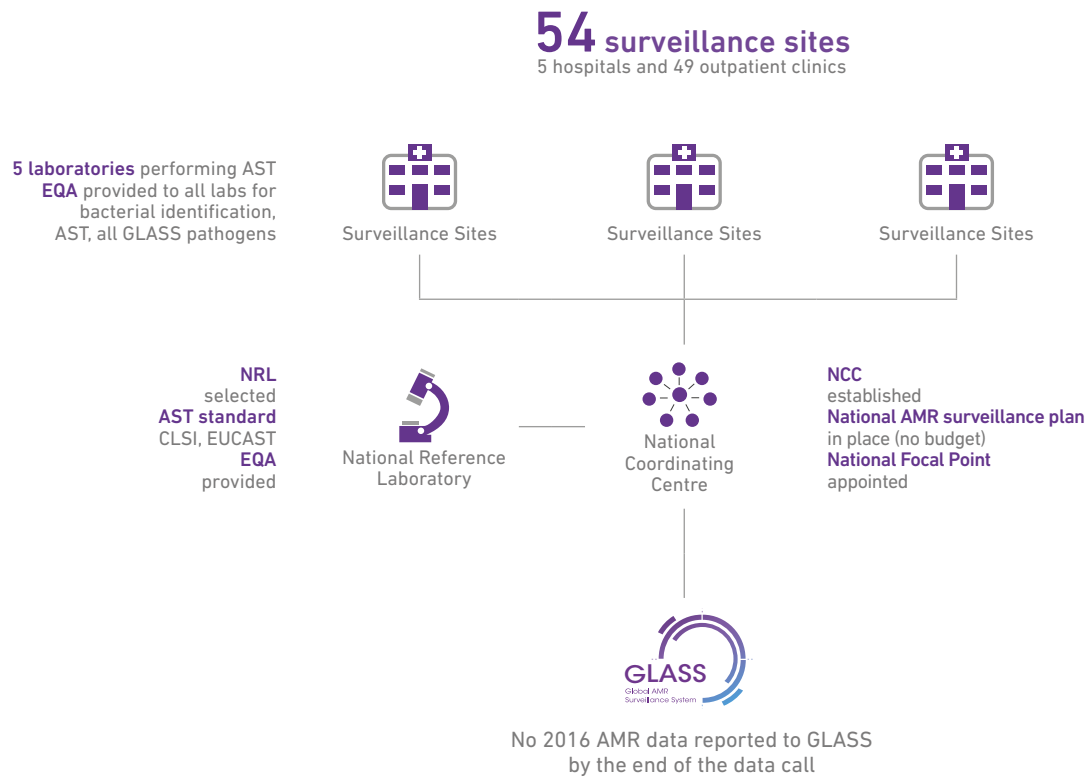

2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

# Cyprus

## Population[1] 0.84 million

The National strategy of Cyprus against microbial resistance to antibiotics was published in 2012. The country participates in the EARS-NET and is enrolled in GLASS since September 2016.

## Current status of the national AMR surveillance system



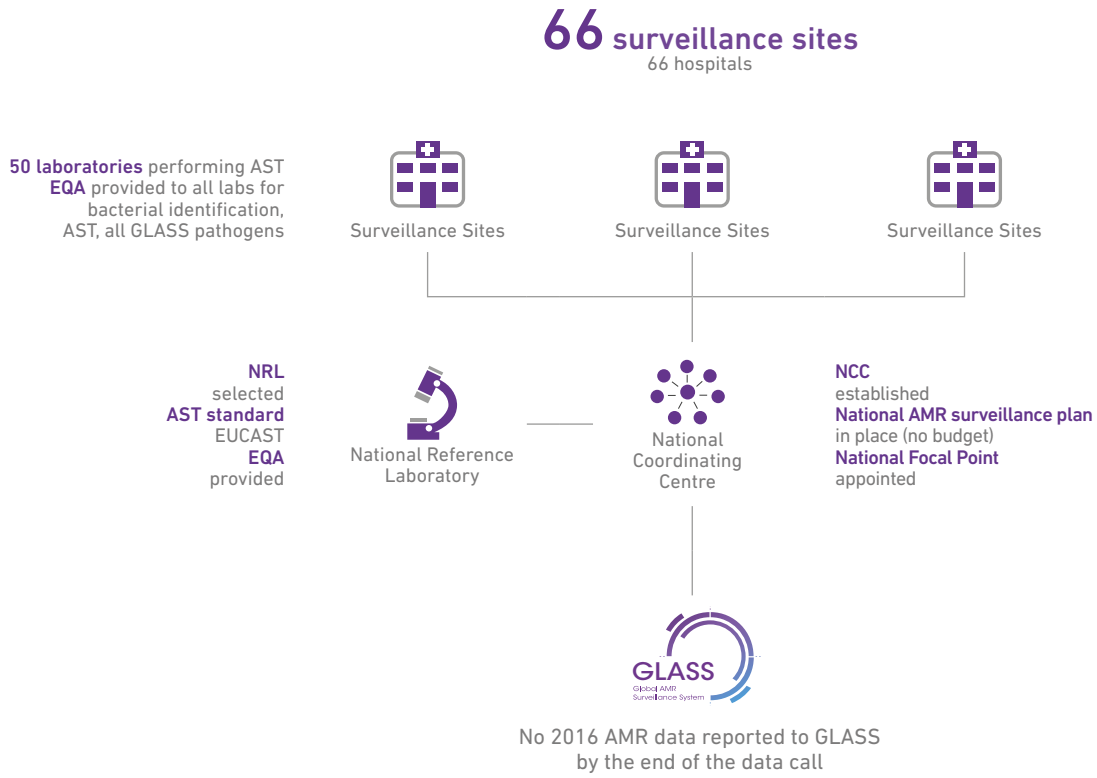

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Czech Republic

## Population[1] 10.60 million

The Czech Republic participates in the EARS-NET. The national AMR surveillance network (CZ-EARSNet) covers almost 80% of the Czech population. The country works on development of a new National Action Plan on AMR. It has been enrolled in GLASS since December 2016.

## Current status of the national AMR surveillance system



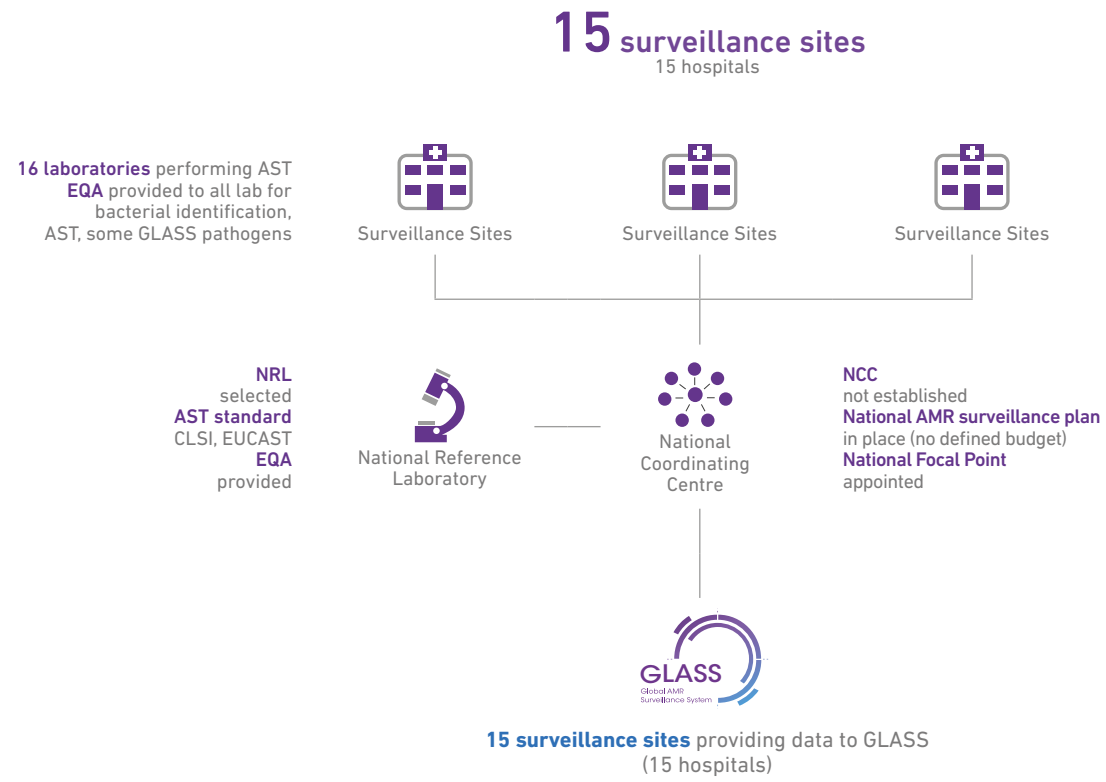

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Egypt

## Population[1] 93.77 million

Egypt is building its national AMR surveillance system. Phase one of the national AMR action plan (2017–2020) has been drafted in 2017. Egypt has been enrolled in GLASS since May 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *E. coli* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟠 | 🟢 |
| | | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *S. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟢 |
| URINE | 🔴 | *E. coli* | 🟢 | 🟠 | 🟠 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟠 | 🟢 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🔴 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Egypt

## Population 93.77 million

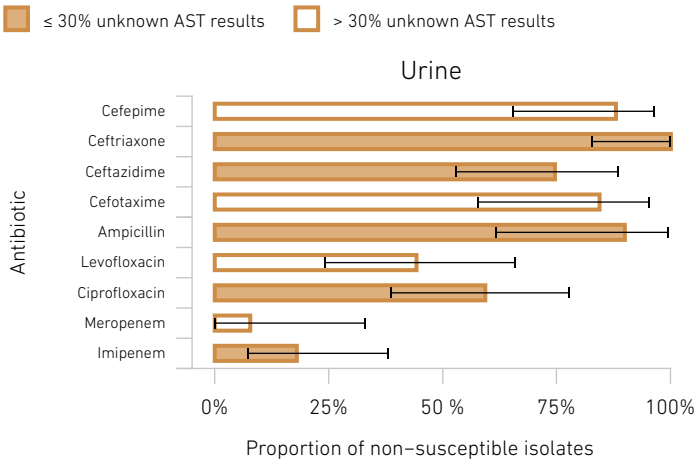
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | 3 | - |
| | | | | *E. coli* | - | 2 | - |
| | | | | *K. pneumoniae* | - | 48 | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | - | 3 | - |
| | | | | *S. pneumoniae* | - | 1 | - |
| URINE | - | - | - | *E. coli* | - | 27 | - |
| | | | | *K. pneumoniae* | - | 34 | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

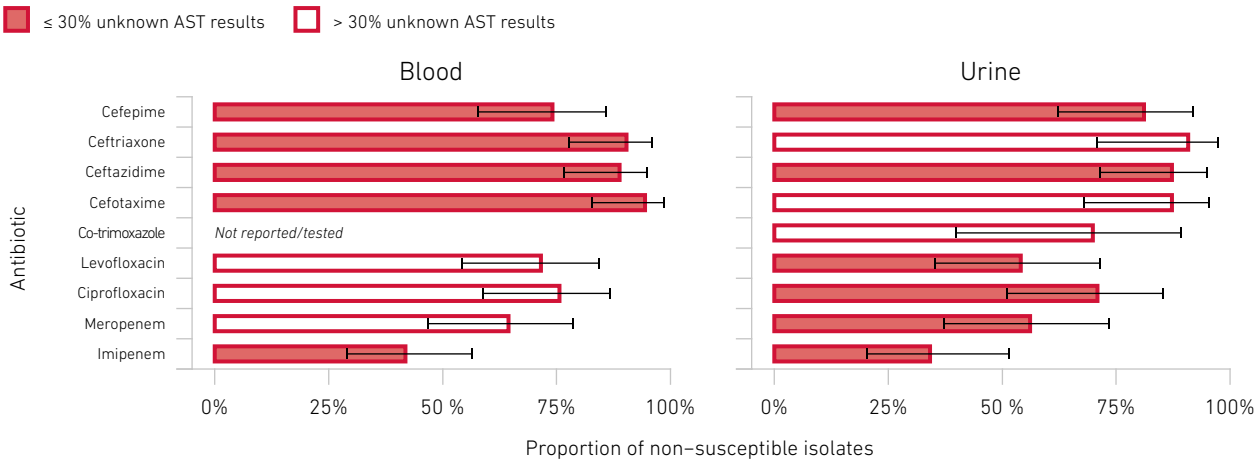
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Escherichia coli*




### *Klebsiella pneumoniae*



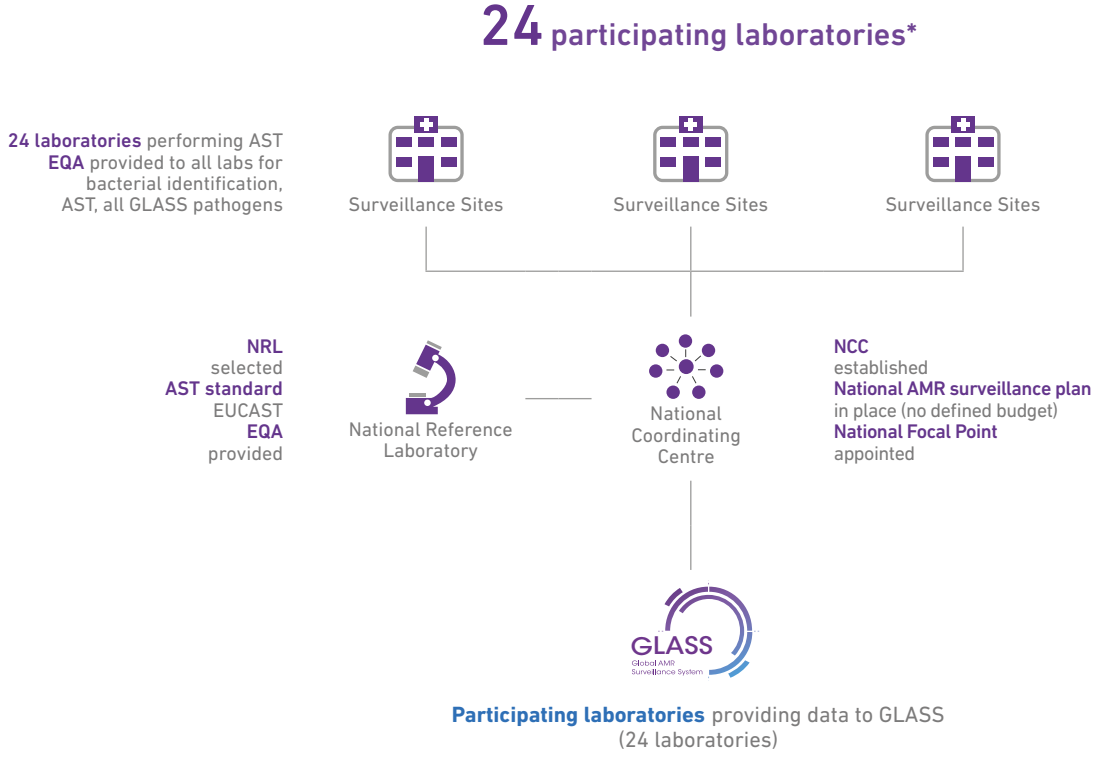

2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

# Finland

## Population[1] 5.48 million

Finland has several surveillance systems monitoring AMR which include, in particular, the Finnish research group studying antimicrobial resistance (FiRe) and the Hospital infection programme (SIRO). FiRe, founded in 1991, collects data on AMR in 15 clinically important bacteria and produces an annual FINRES report. SIRO collects data on AMR in pathogens that cause major healthcare associated infections. The National Action Plan on AMR covers the period 2017-2021. Finland participates in the EARS-NET and has been enrolled in GLASS since October 2016.

## Current status of the national AMR surveillance system




*The identification of the total number of surveillance sites submitting specimens to participating laboratories was not possible due to the set up of the national surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *E. coli* | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *S. pneumoniae* | 🟢 | 🔴 | 🟢 | 🔴 |
| URINE | 🔴 | *E. coli* | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🟢 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Finland

## Population 5.48 million

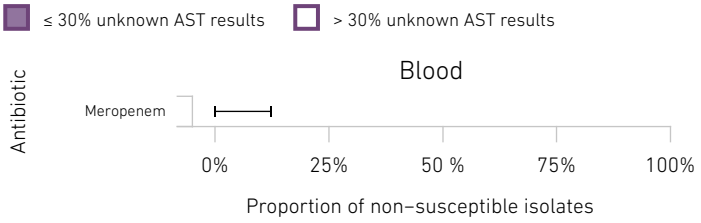
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | 279 131 | *Acinetobacter* spp. | - | - | 27 |
| | | | | *E. coli* | - | - | 4 830 |
| | | | | *K. pneumoniae* | - | - | 763 |
| | | | | *Salmonella* spp. | - | - | 50 |
| | | | | *S. aureus* | - | - | 1 883 |
| | | | | *S. pneumoniae* | - | - | 801 |
| **URINE** | - | - | 1 644 000 | *E. coli* | - | - | 141 843 |
| | | | | *K. pneumoniae* | - | - | 15 834 |
| **STOOL** | - | - | - | *Salmonella* spp. | - | - | 1 081 |
| | | | | *Shigella* spp. | - | - | - |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | - | - | 219 |

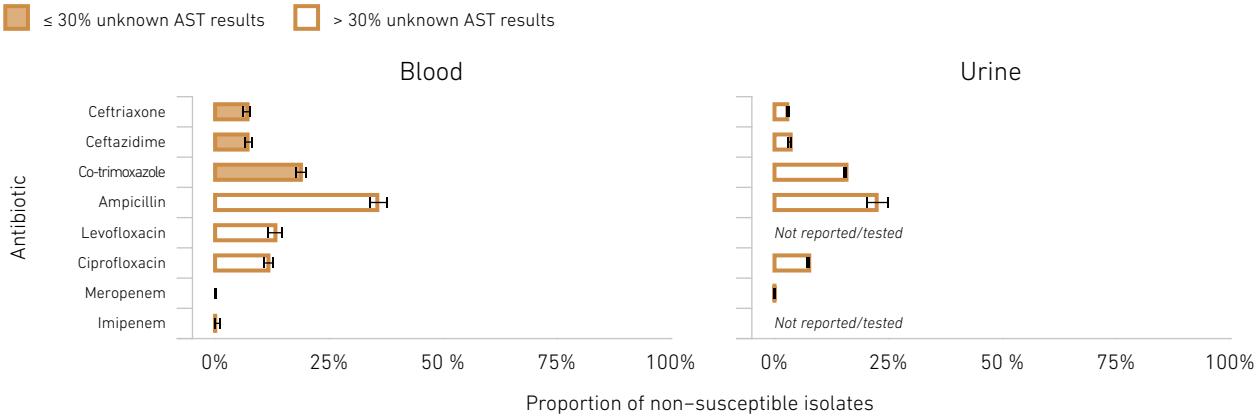
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**




***Escherichia coli***

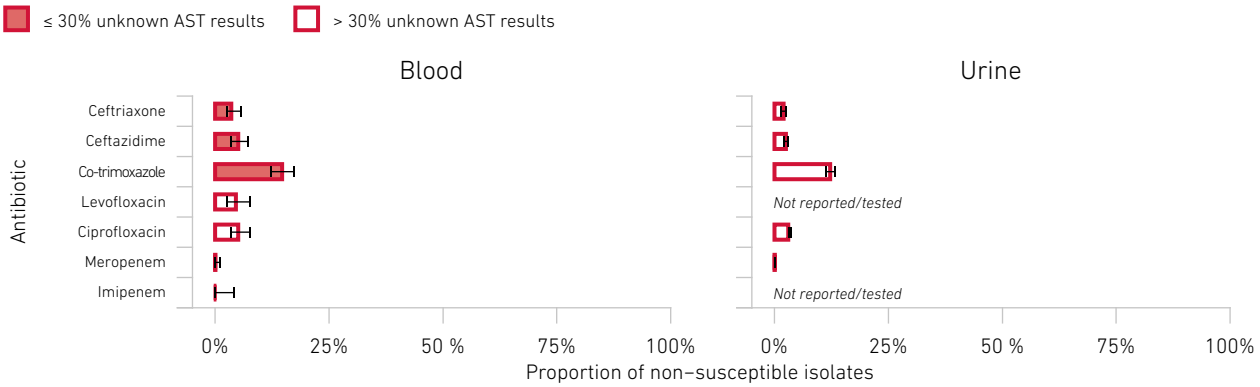



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

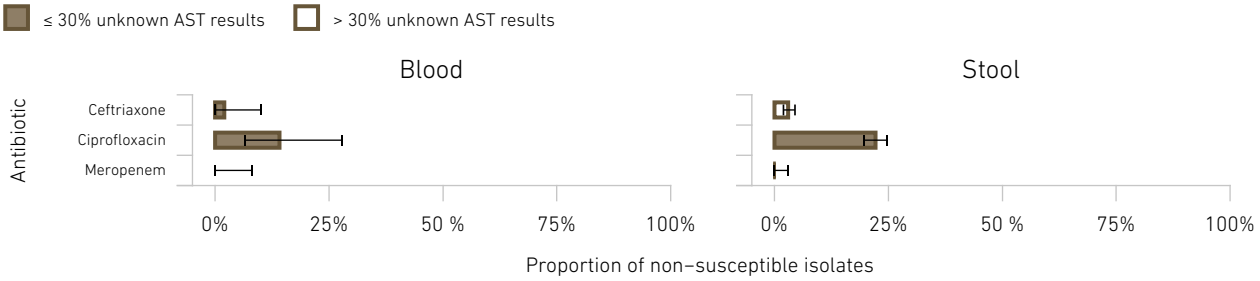
# Finland

## Population 5.48 million

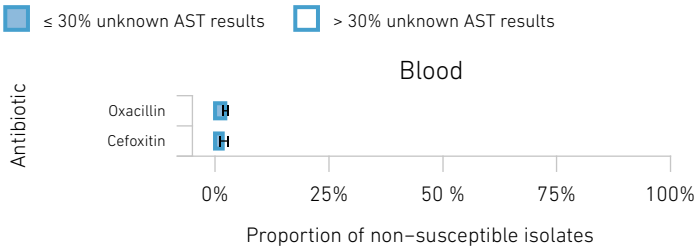
### *Klebsiella pneumoniae*



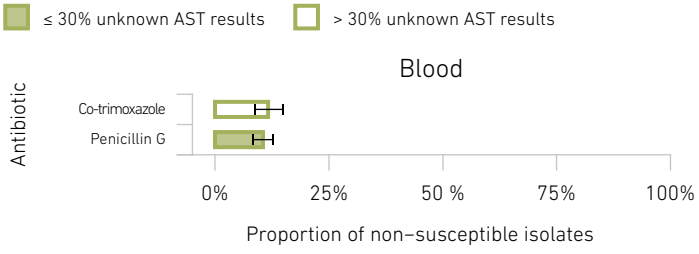

### *Salmonella* spp.



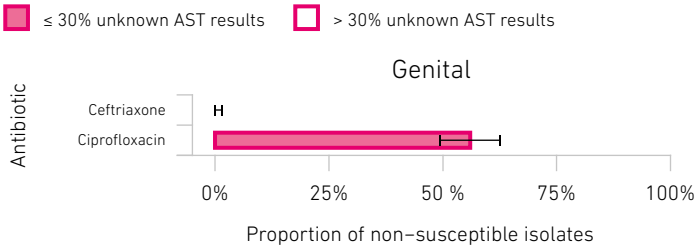

### *Staphylococcus aureus*




### *Streptococcus pneumoniae*




### *Neisseria gonorrhoeae*



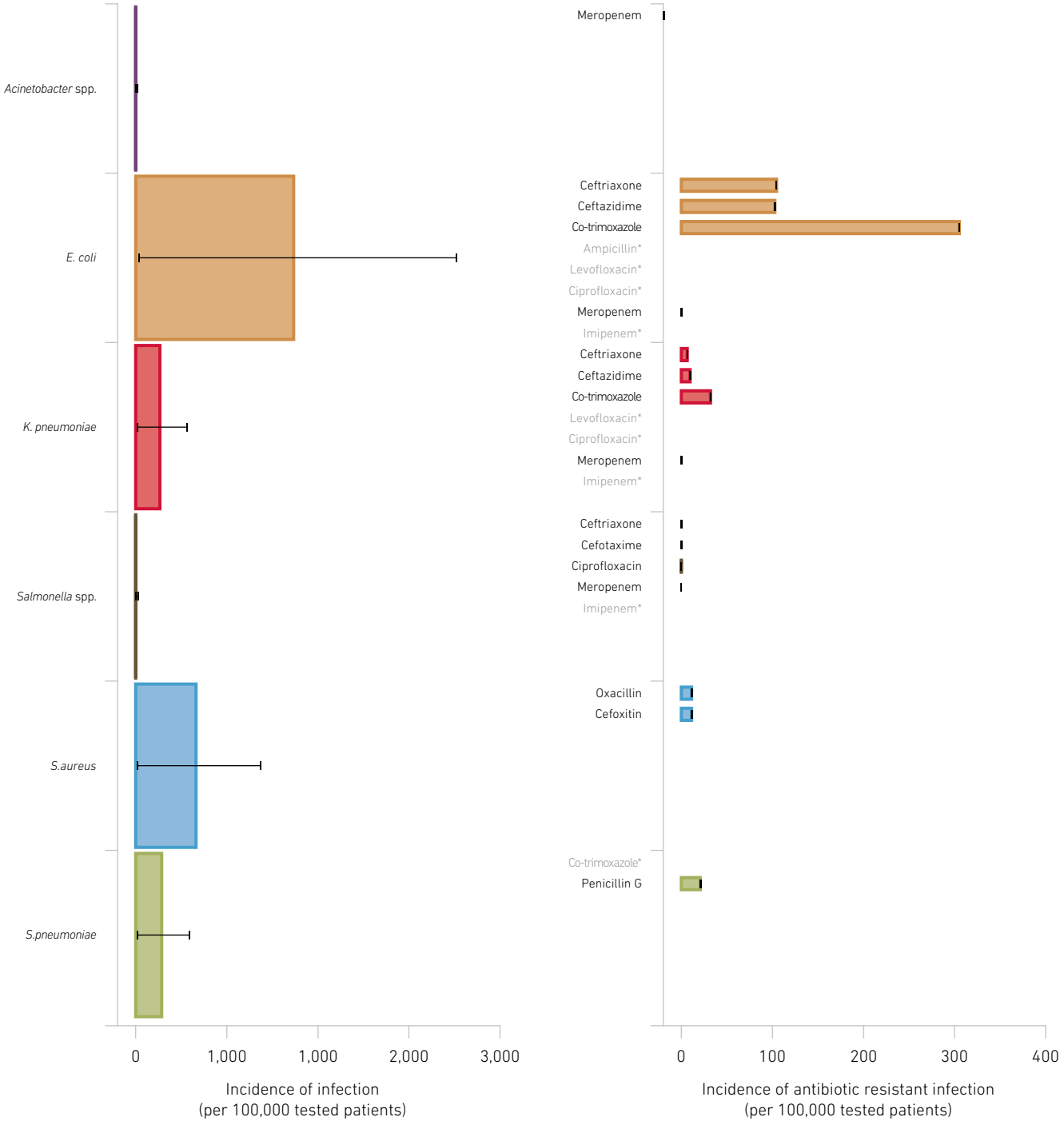
# Finland

## Population 5.48 million

## Non-susceptible pathogen – antimicrobial combination frequency

Incidence of infection caused by pathogens under surveillance, per specimen and infection origin (left)
Incidence of infection caused by pathogens non-susceptible to defined antibiotics under surveillance, per specimen and infection origin (right)

**Blood – Unknown infection origin** (n tested = 279,131)

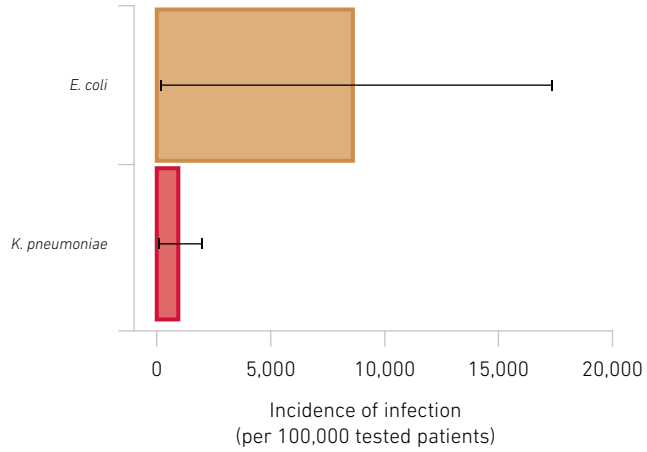


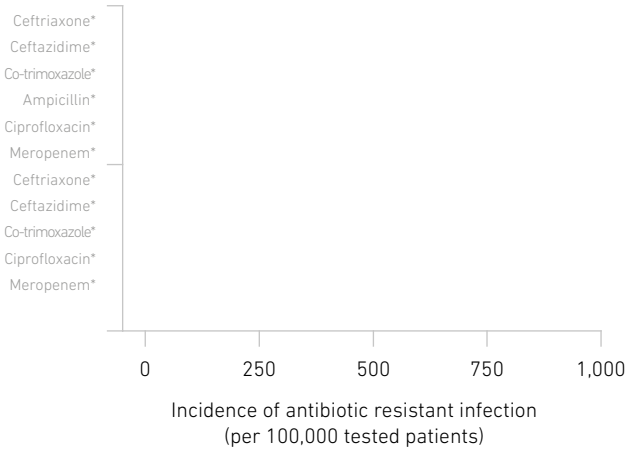

*Antibiotic with >30% unknown AST results - AMR rates not shown

# Finland

## Population 5.48 million

**Urine – Unknown infection origin** (n tested = 1,644,000)




*Antibiotic with >30% unknown AST results - AMR rates not shown

# Georgia

## Population[1] 3.95 million

The AMR National Strategy had been approved in January 2017. AMR surveillance is included in the NAP. Georgia is building its national AMR surveillance system and participates in CAESAR. It has been enrolled in GLASS since April 2016.

## Current status of the national AMR surveillance system

**20** participating laboratories*

**20 laboratories** performing AST
**EQA** provided to all labs for bacterial identification, AST, all GLASS pathogens

Surveillance Sites | Surveillance Sites | Surveillance Sites

**NRL** selected
**AST standard** CLSI, EUCAST
**EQA** provided

National Reference Laboratory

National Coordinating Centre

**NCC** established
**National AMR surveillance plan** in place (no budget)
**National Focal Point** appointed

GLASS

**Participating laboratories** providing data to GLASS (20 laboratories)

* The identification of the total number of surveillance sites submitting specimens to participating laboratories was not possible due to set-up of the National surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *E. coli* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *S. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟢 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *Shigella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🔴 | 🔴 | 🟢 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Georgia

## Population 3.95 million

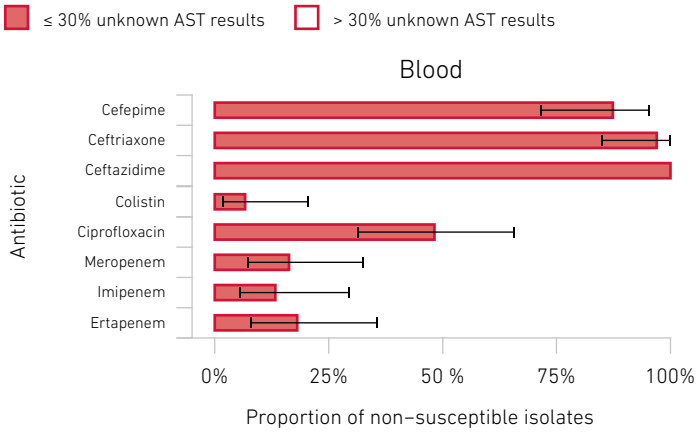
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | - | *Acinetobacter* spp. | 1 | 6 | - |
| | | | | *E. coli* | 6 | 3 | - |
| | | | | *K. pneumoniae* | 15 | 19 | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | 9 | 1 | - |
| | | | | *S. pneumoniae* | 2 | - | - |
| **URINE** | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| **STOOL** | - | - | - | *Salmonella* spp. | 12 | 2 | - |
| | | | | *Shigella* spp. | 53 | 5 | - |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | 26 | - | - |

## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Klebsiella pneumoniae***

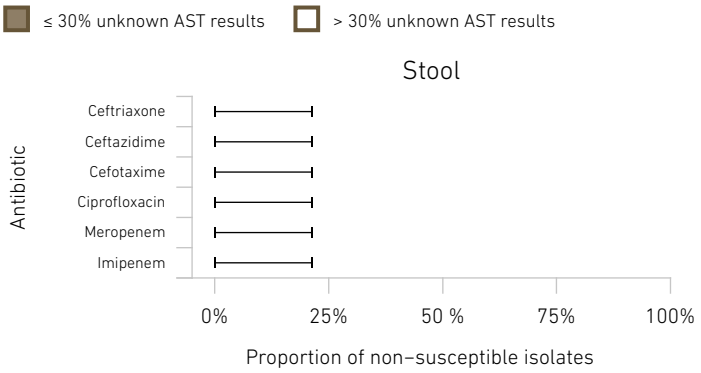



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

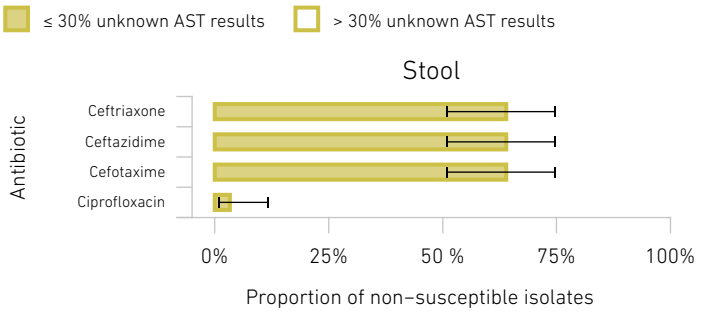
# Georgia

## Population 3.95 million

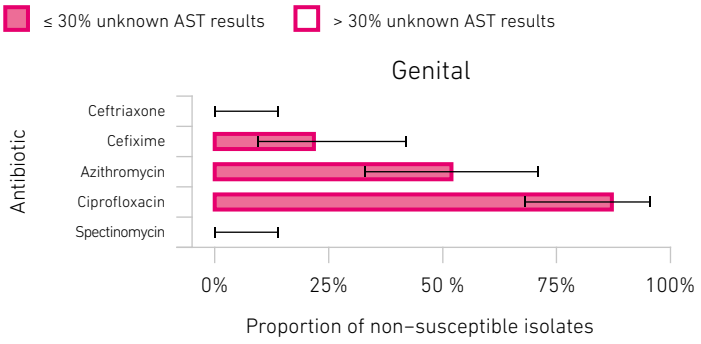
### *Salmonella* spp.




### *Shigella* spp.




### *Neisseria gonorrhoeae*

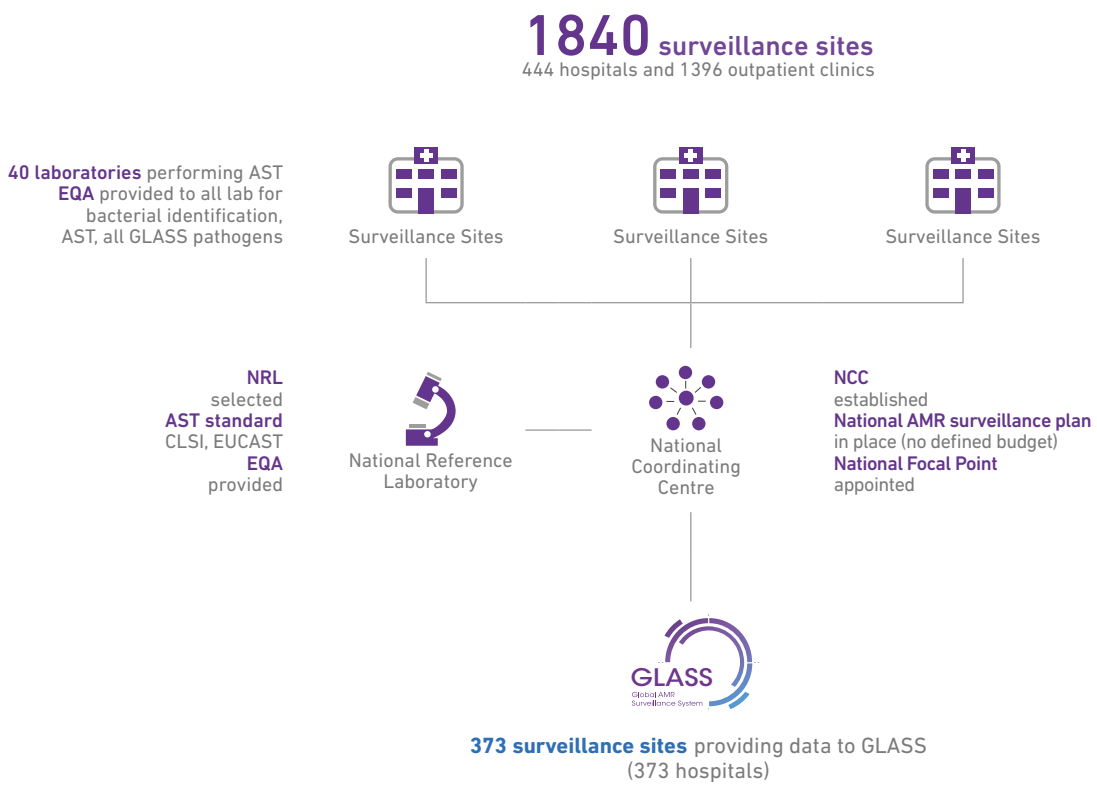


# Germany

## Population[1] 81.70 million

The national surveillance of AMR is coordinated by the Robert Koch Institute, offering a publically accessible interactive database for data of the AMR surveillance system (Antibiotika Resistenz Surveillance – ARS). The National action plan on prevention of AMR (DART 2020) has been published in 2015. Germany participates in the EARS-NET and is enrolled in GLASS since September 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin* |
|---|---|---|---|---|---|---|
| BLOOD | ● | *Acinetobacter* spp. | ● | ● | ● | ● |
| | | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| | | *Salmonella* spp. | ● | ● | ● | ● |
| | | *S. aureus* | ● | ● | ● | ● |
| | | *S. pneumoniae* | ● | ● | ● | ● |
| URINE | ● | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| STOOL | ● | *Salmonella* spp. | ● | ● | ● | ● |
| | | *Shigella* spp. | ● | ● | ● | ● |
| GENITAL | ● | *N. gonorrhoeae* | ● | ● | ● | ● |

● 100% data collected ● 99-70% data collected ● <70% data collected

* According to the EARS-Net definition for INPAT/OUTPAT (variable PATIENTType).

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Germany

## Population 81.70 million

## Data overview - collection between January and December 2016

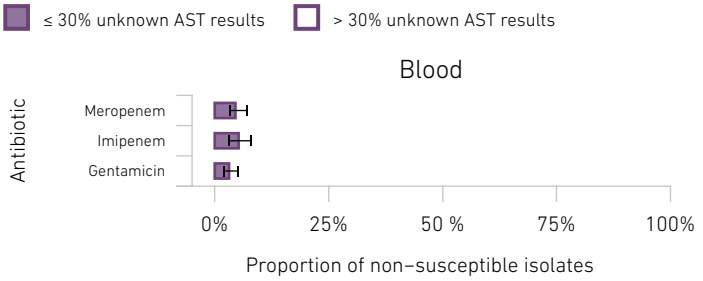
| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin* | Hospital origin* | Unknown origin* |
| BLOOD | - | - | - | *Acinetobacter* spp. | 25 | 402 | 7 |
| | | | | *E. coli* | 1 956 | 13 688 | 241 |
| | | | | *K. pneumoniae* | 296 | 2 497 | 30 |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | 587 | 8 449 | 118 |
| | | | | *S. pneumoniae* | 202 | 1 027 | 16 |
| URINE | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

* According to the EARS-Net definition for INPAT/OUTPAT (variable PATIENTType).

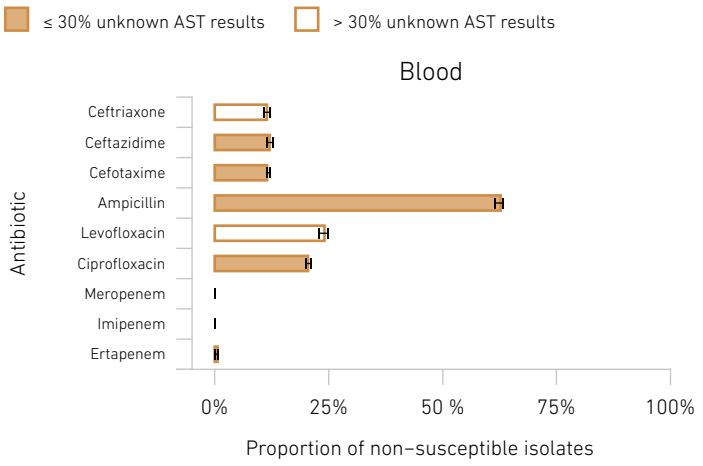
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Acinetobacter* spp.




### *Escherichia coli*

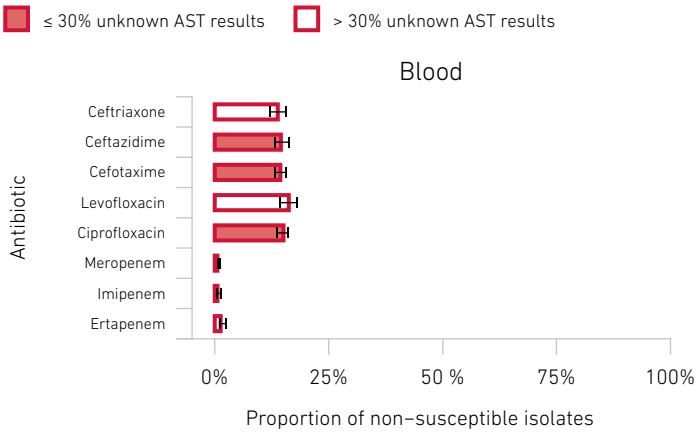



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

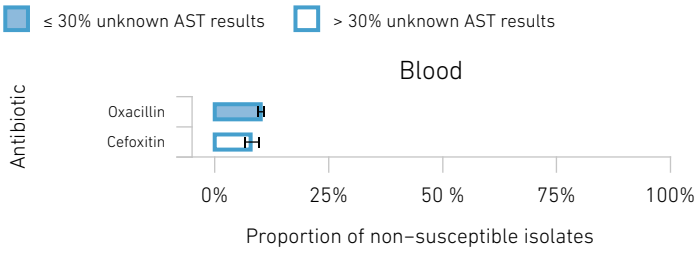
# Germany

## Population 81.70 million

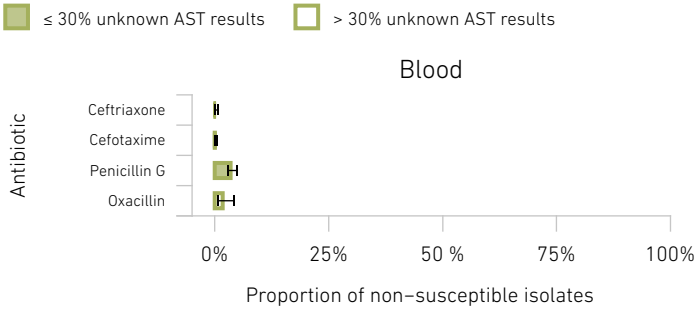
***Klebsiella pneumoniae***




***Staphylococcus aureus***




***Streptococcus pneumoniae*** (n tested = 1245)



# Iran (Islamic Republic of)

## Population[1] 79.36 million

Iran has developed its National Action Plan on AMR with promotion and development of AMR surveillance included in the NAP. Iran has been enrolled in GLASS since May 2016.

## Current status of the national AMR surveillance system

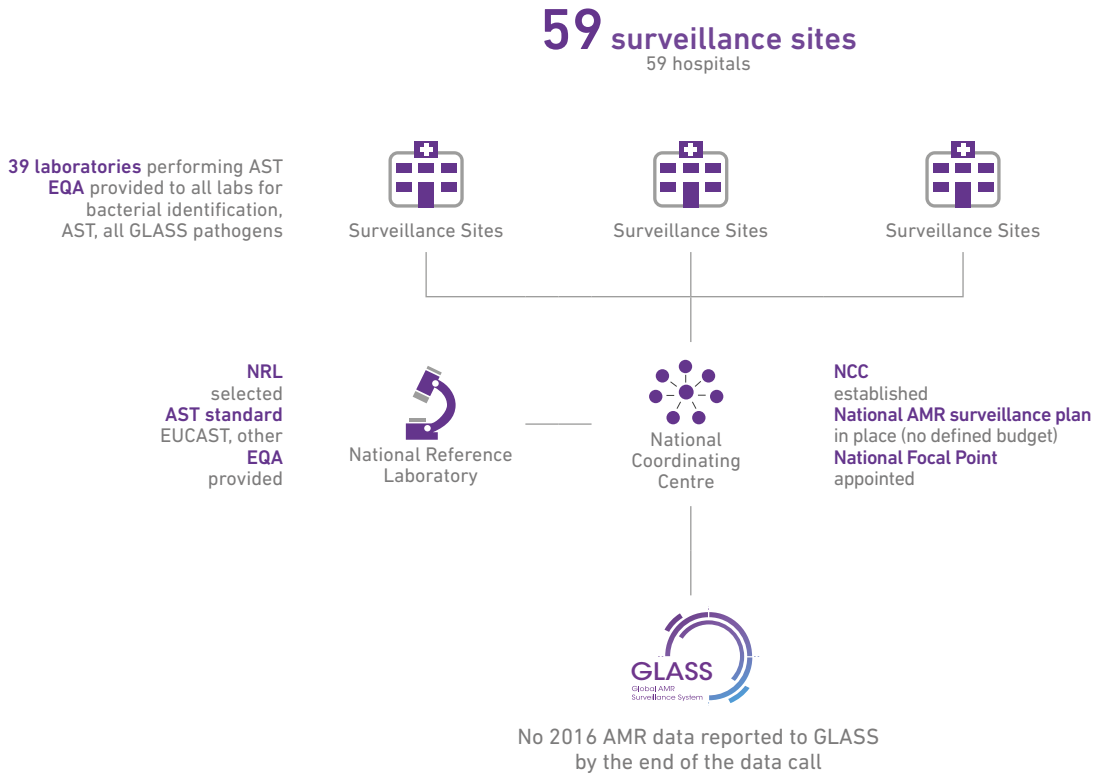

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Ireland

## Population[1] 4.76 million

The national AMR surveillance in Ireland is coordinated by the Health Protection Surveillance Centre (HPSC). Ireland has developed its National Action Plan on AMR for the period of 2017-2020. The country participates in the EARS-NET and has been enrolled in GLASS since July 2016.

## Current status of the national AMR surveillance system




1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

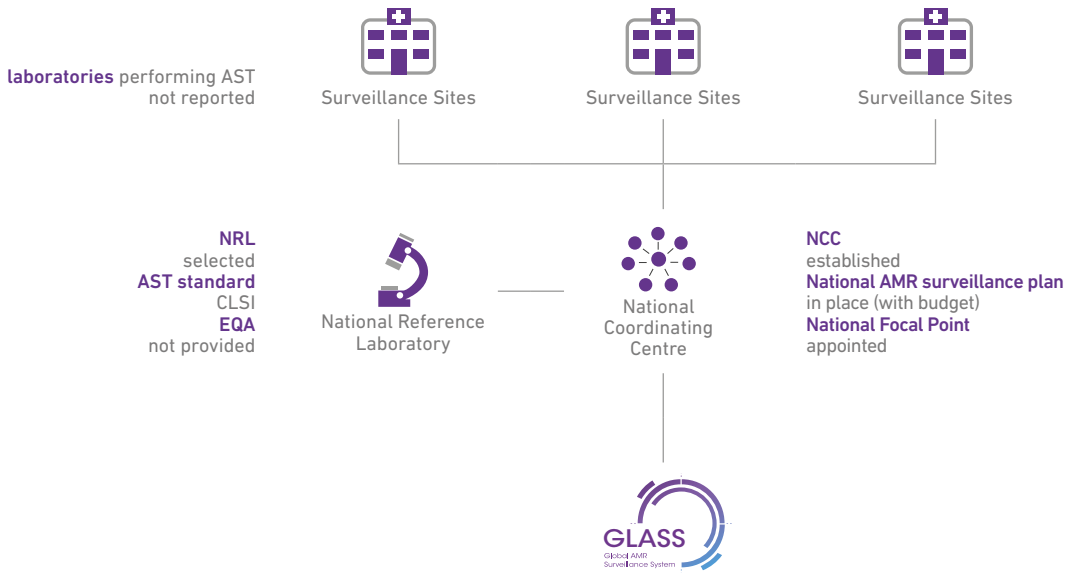
# Japan

## Population[1] 127.95 million

Japan Nosocomial Infections Surveillance (JANIS) is a national surveillance program launched in 2000. It collects surveillance data online from more than 1,000 hospitals across Japan and it produces regular surveillance reports for participating hospitals and for the public. Japan implements the National Action Plan on AMR (2016-2020). The country has been enrolled in GLASS since November 2016.

## Current status of the national AMR surveillance system

**Not reported**




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🟢 | 🔴 | 🔴 | 🟢 |
| GENITAL | 🟢 | *N. gonorrhoeae* | 🟢 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Japan

## Population 127.95 million

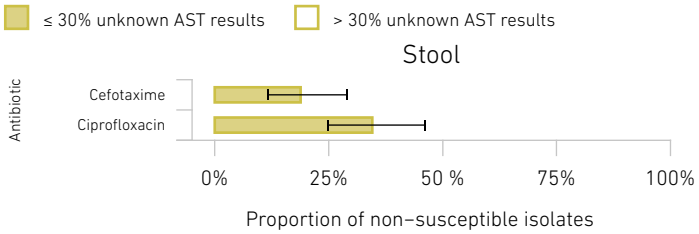
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | - | *Acinetobacter* spp. | - | - | - |
| | | | | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | - | - | - |
| | | | | *S. pneumoniae* | - | - | - |
| **URINE** | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| **STOOL** | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | 75 | - | - |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | - | - | 675 |

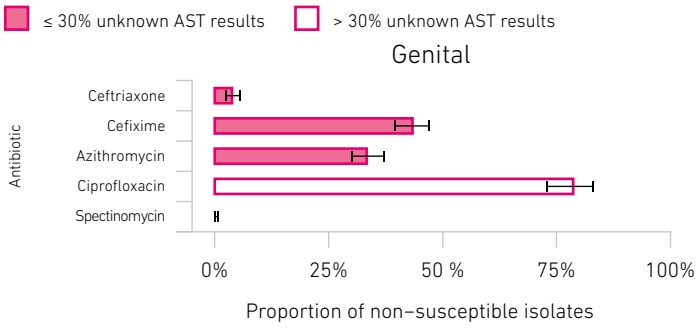
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Shigella* spp.**




***Neisseria gonorrhoeae***



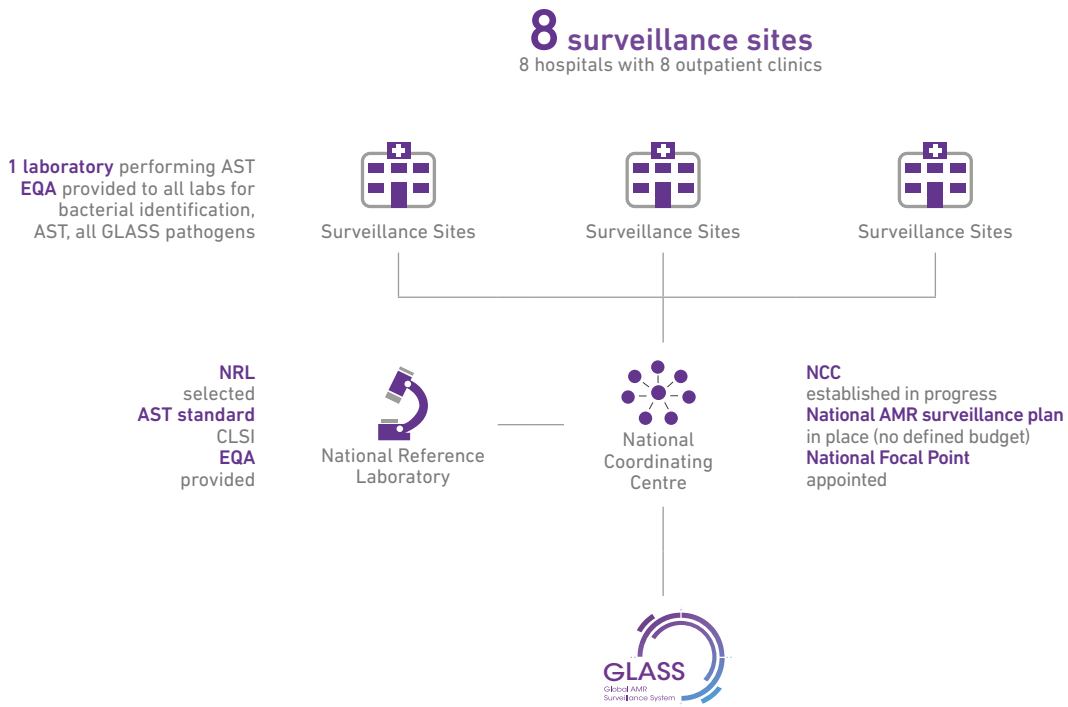

2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

# Kenya

## Population[1] 47.23 million

Kenya has developed and approved the National Policy and Action Plan on AMR and is building its national AMR surveillance system, using the National Antimicrobial Survey Strategy. Kenya has enrolled in GLASS in May 2016.

## Current status of the national AMR surveillance system




No 2016 AMR data reported to GLASS by the end of the data call

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Latvia

## Population[1] 1.99 million

The country participates in the EARS-NET and has been enrolled in GLASS since December 2016.

## Current status of the national AMR surveillance system


## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *E. coli* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟢 | 🟢 |
| | | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *S. aureus* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *S. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟠 |
| URINE | 🔴 | *E. coli* | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟢 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🔴 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Latvia

## Population 1.99 million

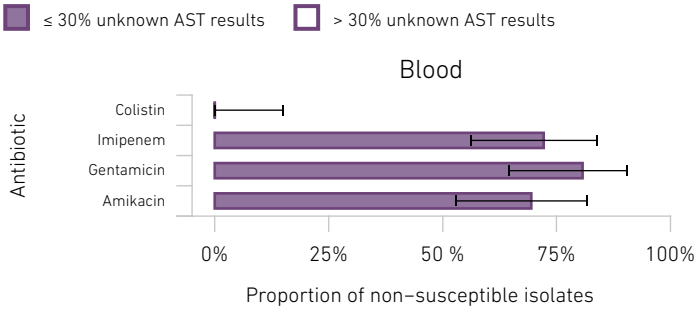
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | 3 749 | *Acinetobacter* spp. | 3 | 33 | - |
| | | | | *E. coli* | 56 | 29 | - |
| | | | | *K. pneumoniae* | 17 | 26 | - |
| | | | | *Salmonella* spp. | 1 | - | - |
| | | | | *S. aureus* | 53 | 48 | - |
| | | | | *S. pneumoniae* | 9 | 2 | 1 |
| **URINE** | - | - | 3 386 | *E. coli* | 583 | 147 | - |
| | | | | *K. pneumoniae* | 95 | 52 | - |
| **STOOL** | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | - | - | - |

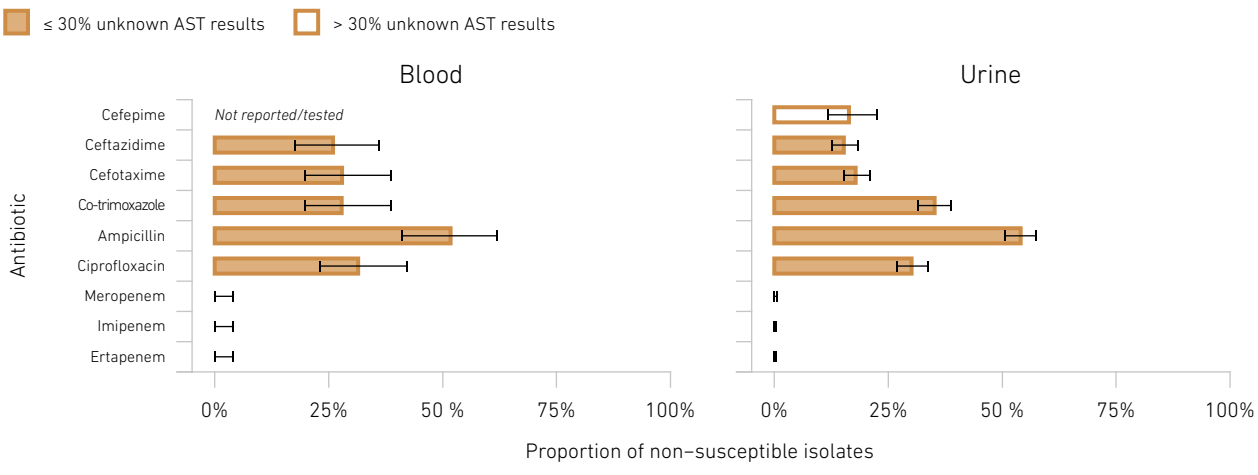
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**




***Escherichia coli***

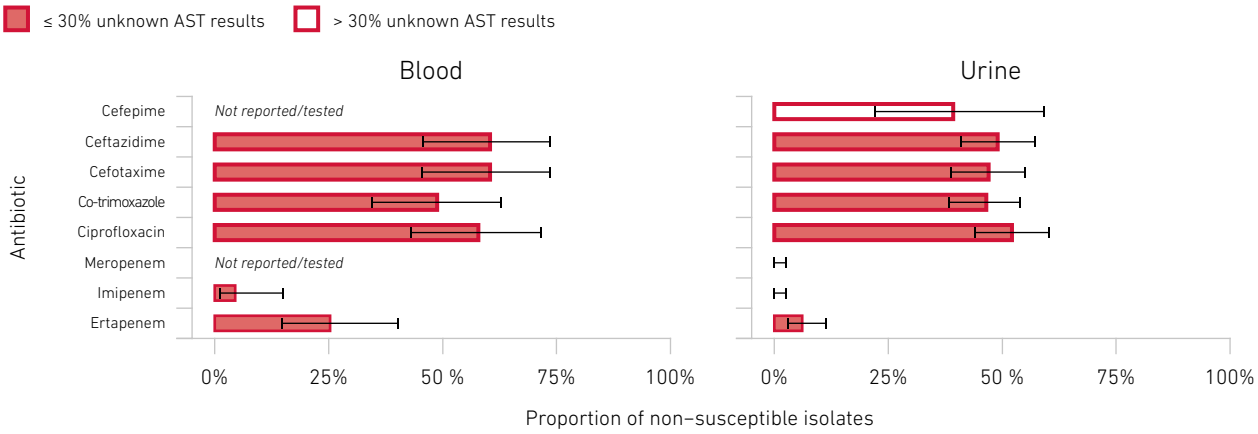



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

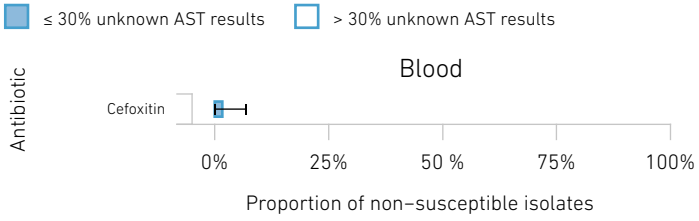
# Latvia

## Population 1.99 million

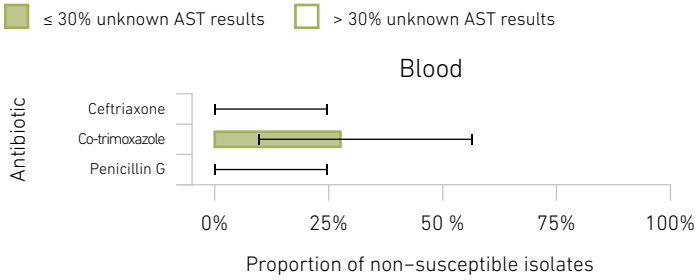
### *Klebsiella pneumoniae*




### *Staphylococcus aureus*




### *Streptococcus pneumoniae*



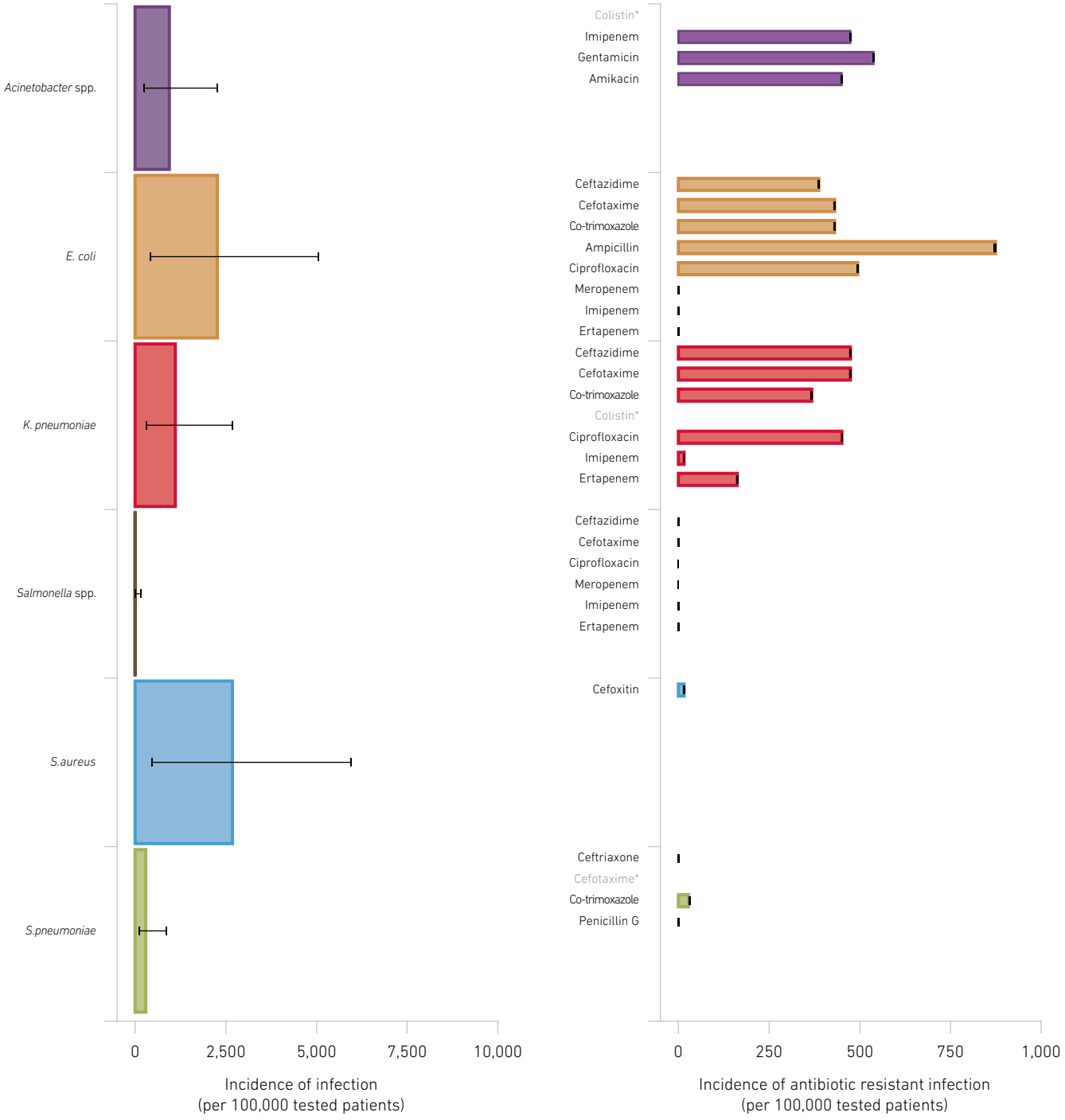
# Latvia

## Population 1.99 million

## Non-susceptible pathogen – antimicrobial combination incidence

Incidence of infection caused by pathogens under surveillance, per specimen and infection origin (left).
Incidence of infection caused by pathogens non-susceptible to defined antibiotics under surveillance, per specimen and infection origin (right).

**Blood – Unknown infection origin** (n tested = 3749)

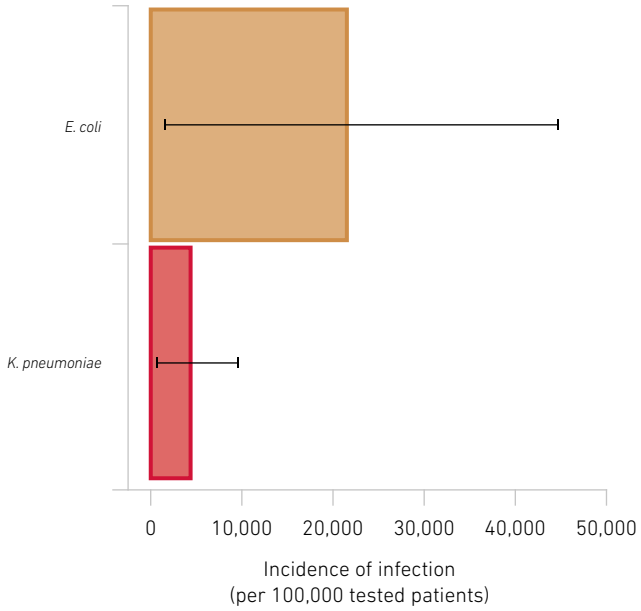


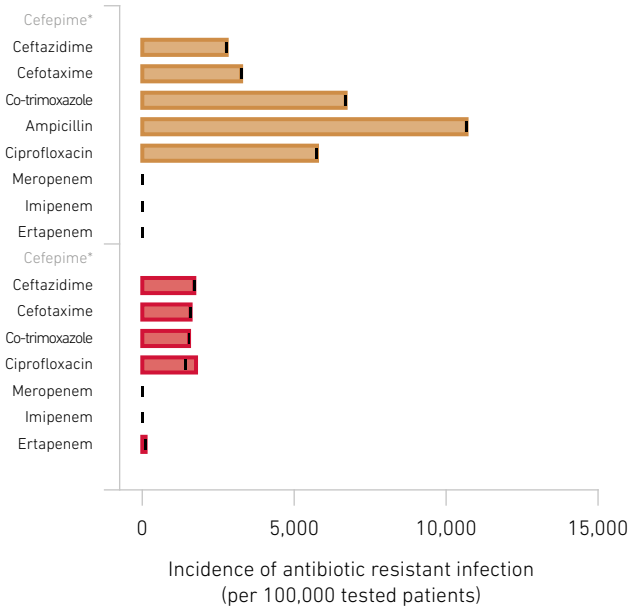

*Antibiotic with >30% unknown AST results - AMR rates not shown

# Latvia

## Population 1.99 million

**Urine – Unknown infection origin** (n tested = 3386)



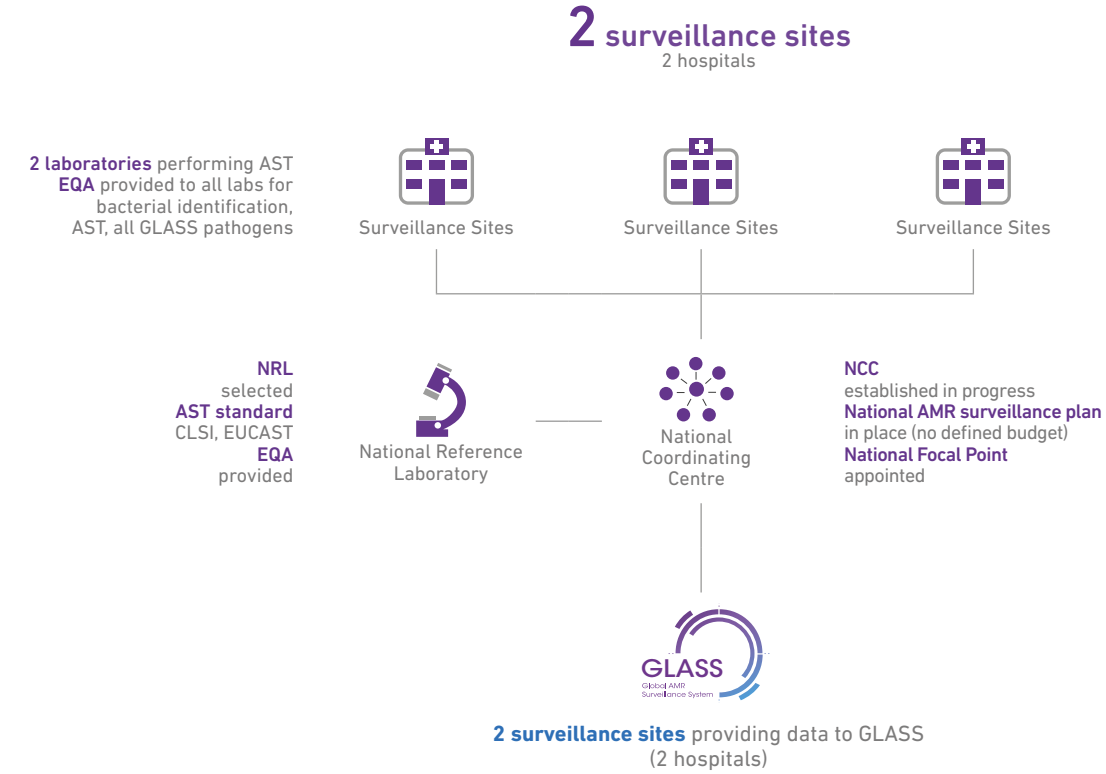

*Antibiotic with >30% unknown AST results - AMR rates not shown

# Lebanon

## Population[1] 5.85 million

Lebanon is developing a National Action Plan on AMR. The country has been enrolled in GLASS since April 2017.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *E. coli* | 🟢 | 🟠 | 🟠 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🟢 | 🟠 | 🟠 | 🔴 |
| | | *S. pneumoniae* | 🟢 | 🟠 | 🟠 | 🔴 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🟠 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🟢 | 🟠 | 🟠 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🟢 | 🟢 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Lebanon

## Population 5.85 million

## Data overview - collection between January and December 2016

Data was reported in two batches.

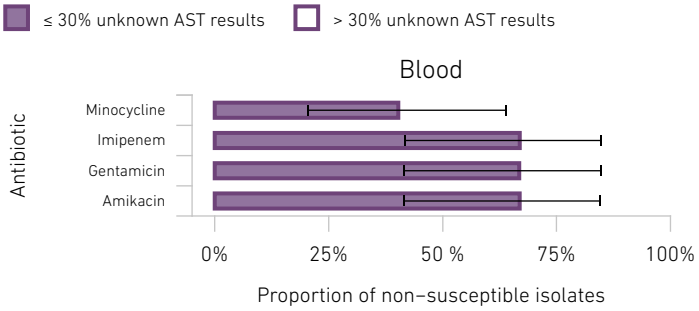
| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin (batch1/batch 2) |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | 15/0 |
| | | | | *E. coli* | - | - | 58/16 |
| | | | | *K. pneumoniae* | - | - | 15/0 |
| | | | | *Salmonella* spp. | - | - | 12/1 |
| | | | | *S. aureus* | - | - | 9/5 |
| | | | | *S. pneumoniae* | - | - | 6/2 |
| URINE | - | - | - | *E. coli* | - | - | 874/118 |
| | | | | *K. pneumoniae* | - | - | 142/0 |
| STOOL | - | - | - | *Salmonella* spp. | - | - | 28/8 |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

## Pathogens non-susceptibility overview[2]

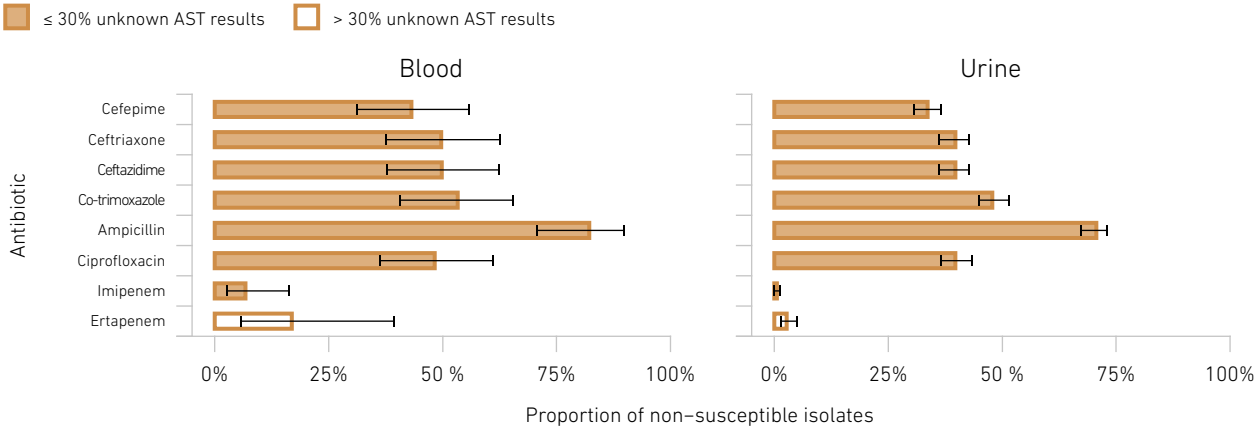
Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

Batch 1

***Acinetobacter* spp.**




***Escherichia coli***

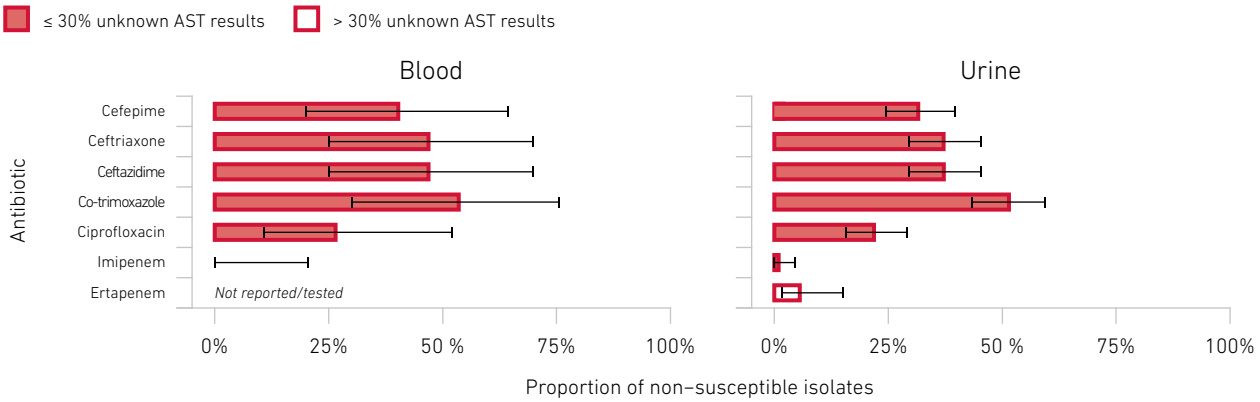



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

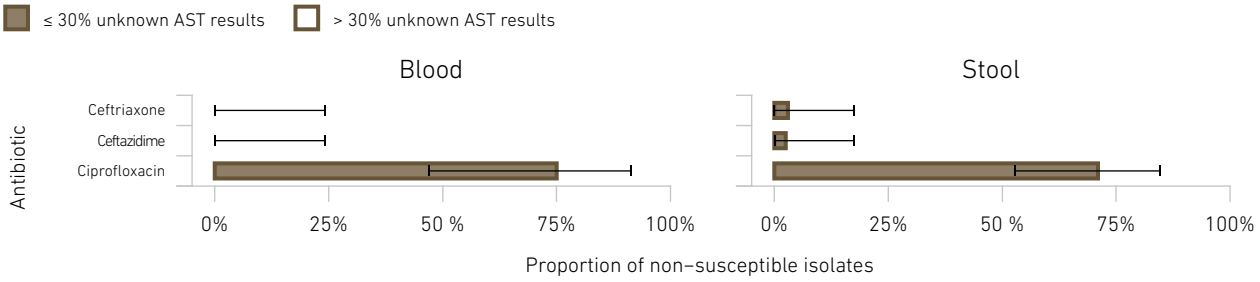
# Lebanon

## Population 5.85 million

***Klebsiella pneumoniae***

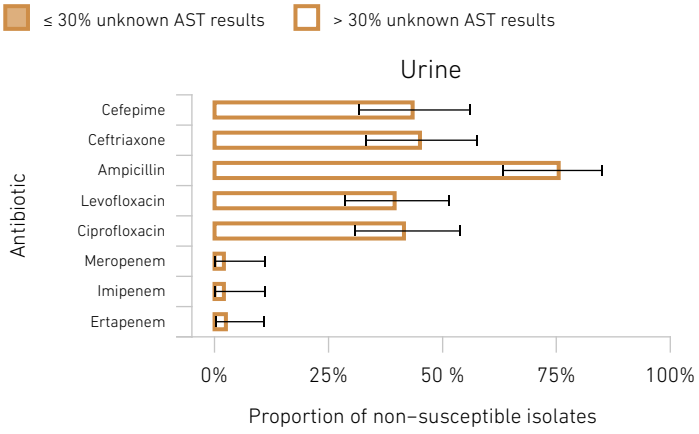



***Salmonella* spp.**




Batch 2

***Escherichia coli***



# Luxembourg

## Population[1] 0.56 million

The country participates in the EARS-NET and has been enrolled in GLASS since June 2016.

## Current status of the national AMR surveillance system

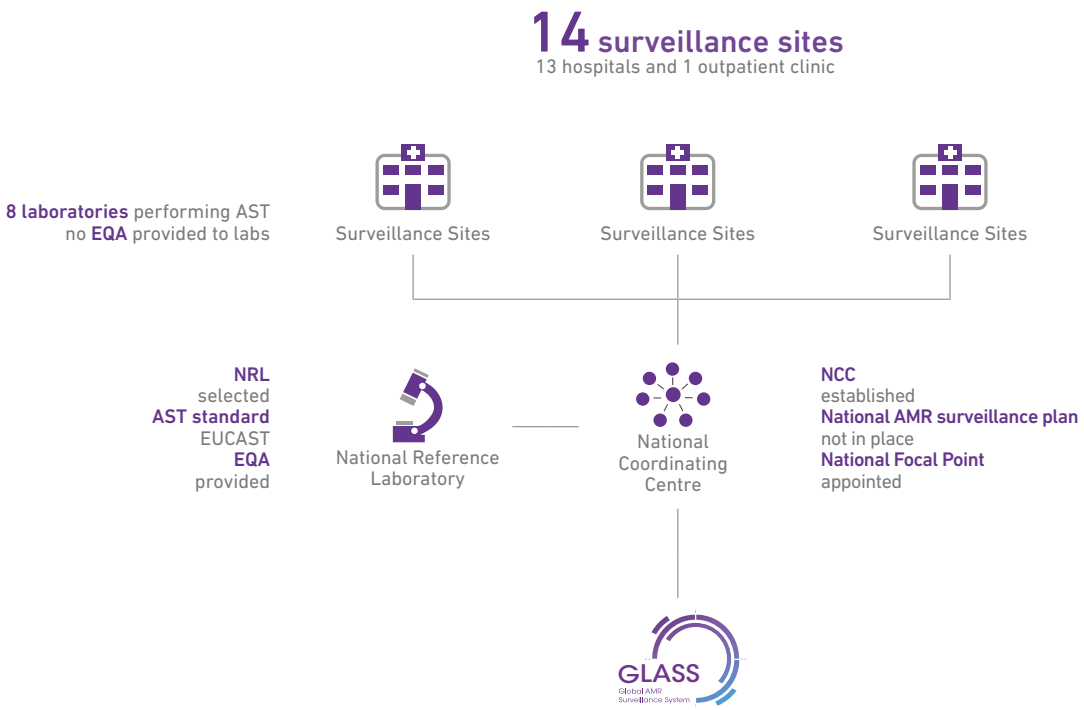

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Madagascar

## Population[1] 24.23 million

Madagascar is developing its National Action Plan on AMR and is building a national AMR surveillance system. The country has enrolled in GLASS in July 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🟢 | 🟠 | 🟠 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟠 | 🟢 |
| | | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *S. aureus* | 🟢 | 🟠 | 🟠 | 🟢 |
| | | *S. pneumoniae* | 🟢 | 🔴 | 🔴 | 🟢 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| | | *Shigella* spp. | 🟢 | 🟢 | 🟢 | 🟢 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🟢 | 🟢 | 🟢 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Madagascar

## Population 24.23 million

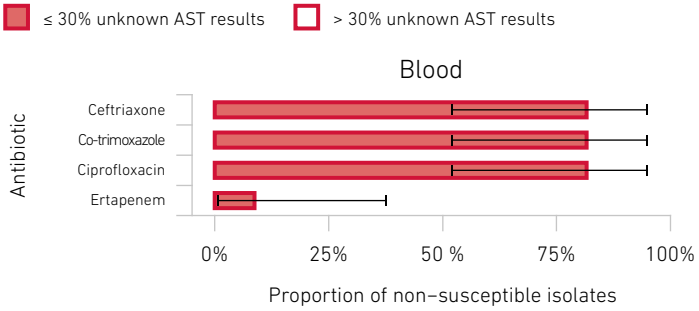
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | - |
| | | | | *E. coli* | 8 | - | - |
| | | | | *K. pneumoniae* | 11 | - | - |
| | | | | *Salmonella* spp. | 5 | - | - |
| | | | | *S. aureus* | 10 | - | - |
| | | | | *S. pneumoniae* | 2 | - | - |
| URINE | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| STOOL | - | - | - | *Salmonella* spp. | 1 | - | - |
| | | | | *Shigella* spp. | 6 | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | 35 | - | - |

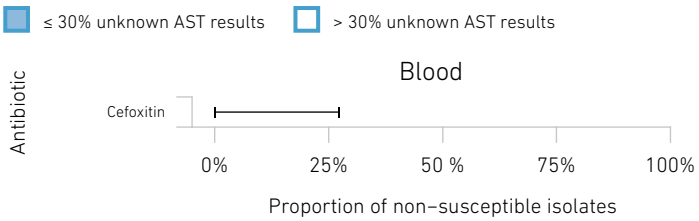
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

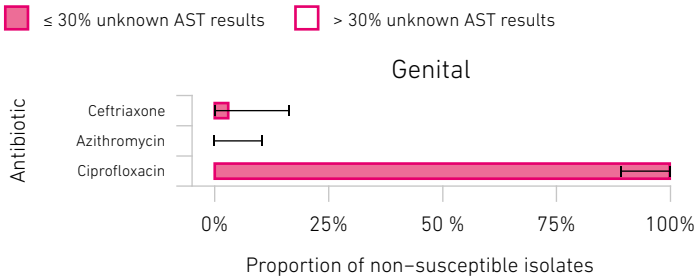
***Klebsiella pneumoniae***




***Staphylococcus aureus***




***Neisseria gonorrhoeae***



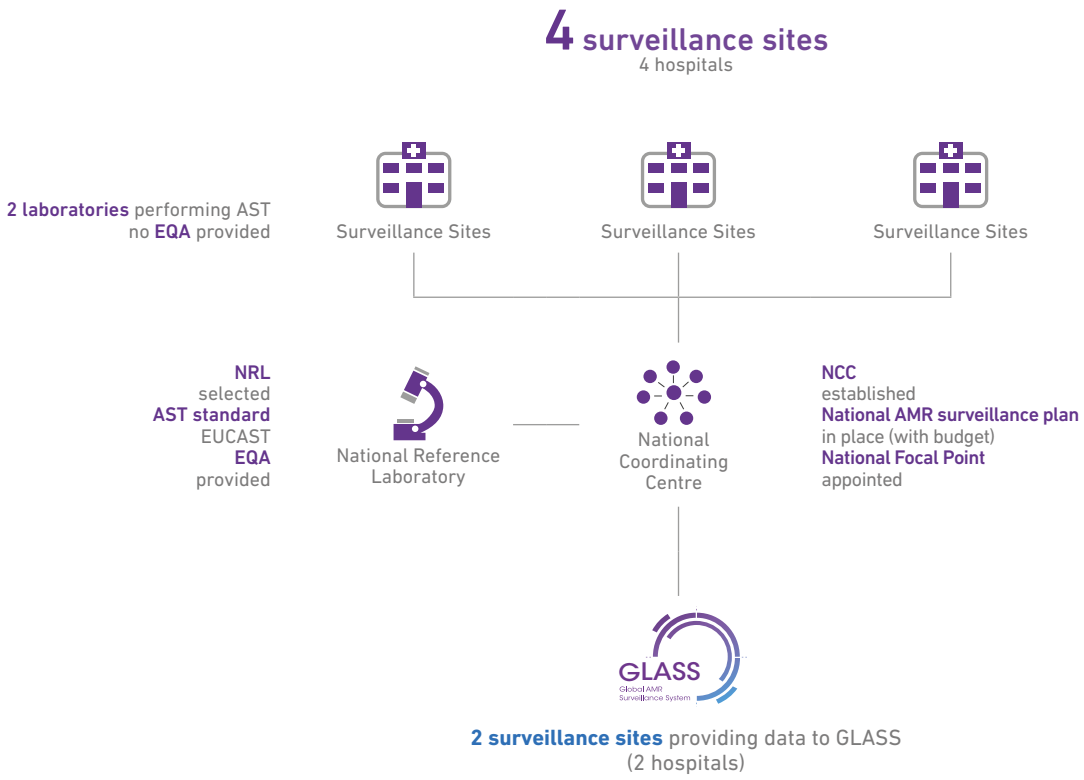

2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

# Malawi

## Population[1] 17.54 million

Malawi is developing its National Action Plan on AMR and is building a national AMR surveillance system. Malawi has been enrolled in GLASS since May 2017.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *S. pneumoniae* | 🟢 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Malawi

## Population 17.54 million

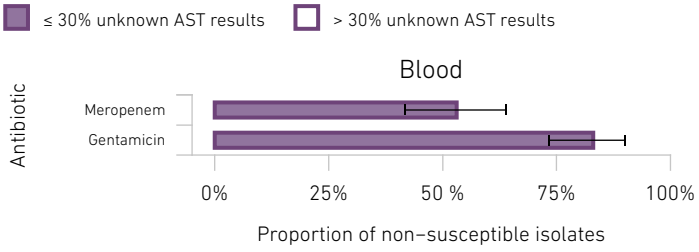
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | 72 |
| | | | | *E. coli* | - | - | 405 |
| | | | | *K. pneumoniae* | - | - | 126 |
| | | | | *Salmonella* spp. | - | - | 122 |
| | | | | *S. aureus* | - | - | 245 |
| | | | | *S. pneumoniae* | - | - | 463 |
| URINE | - | - | - | *E. coli* | - | - | 252 |
| | | | | *K. pneumoniae* | - | - | 47 |
| STOOL | - | - | - | *Salmonella* spp. | - | - | 83 |
| | | | | *Shigella* spp. | - | - | 110 |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | 413 |

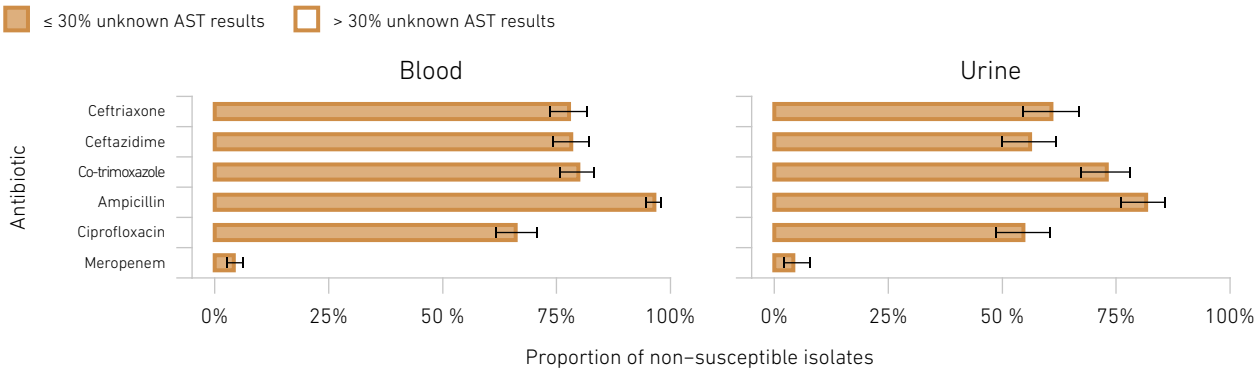
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Acinetobacter* spp.




### *Escherichia coli*

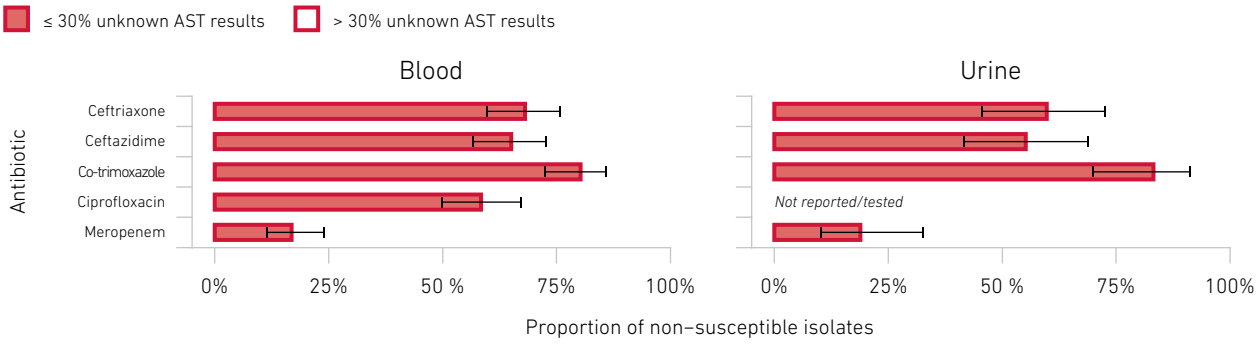



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

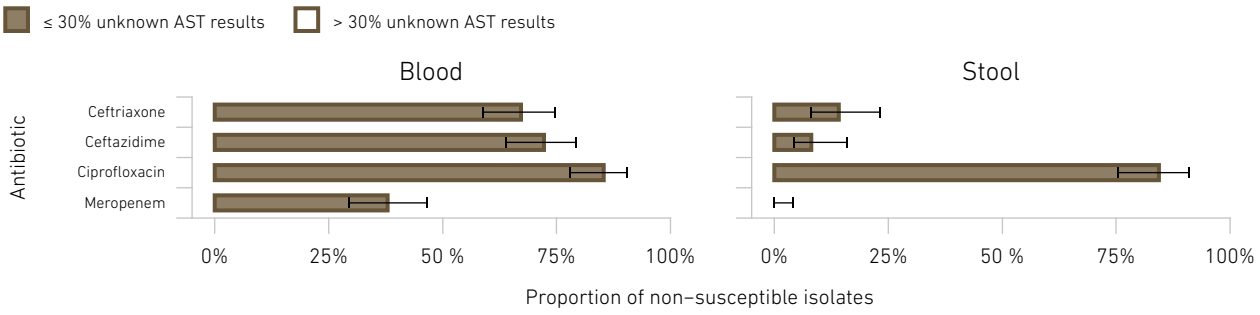
# Malawi

## Population 17.54 million

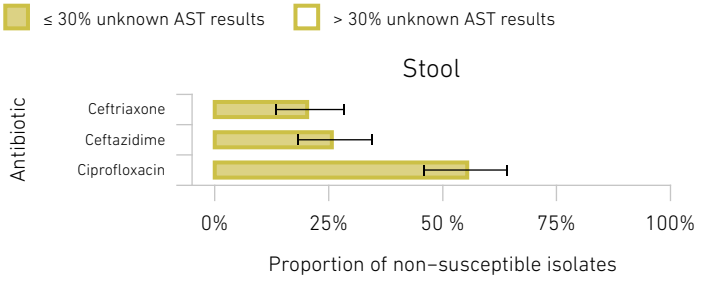
### *Klebsiella pneumoniae*



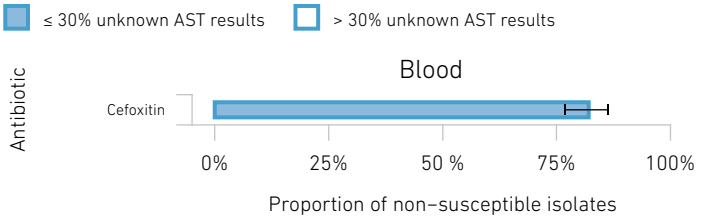

### *Salmonella* spp.



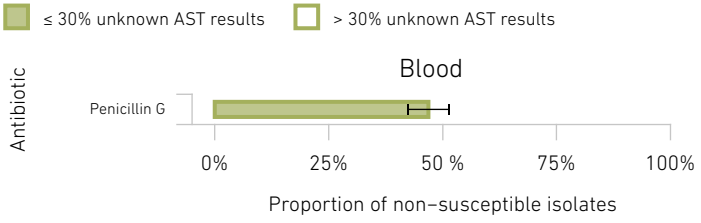

### *Shigella* spp.




### *Staphylococcus aureus*



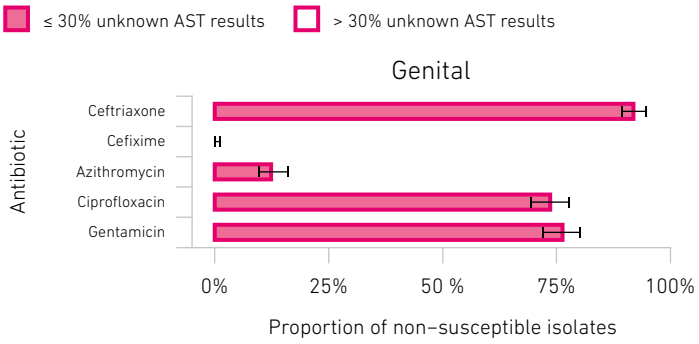

### *Streptococcus pneumoniae*



# Malawi

## Population 17.54 million

***Neisseria gonorrhoeae***

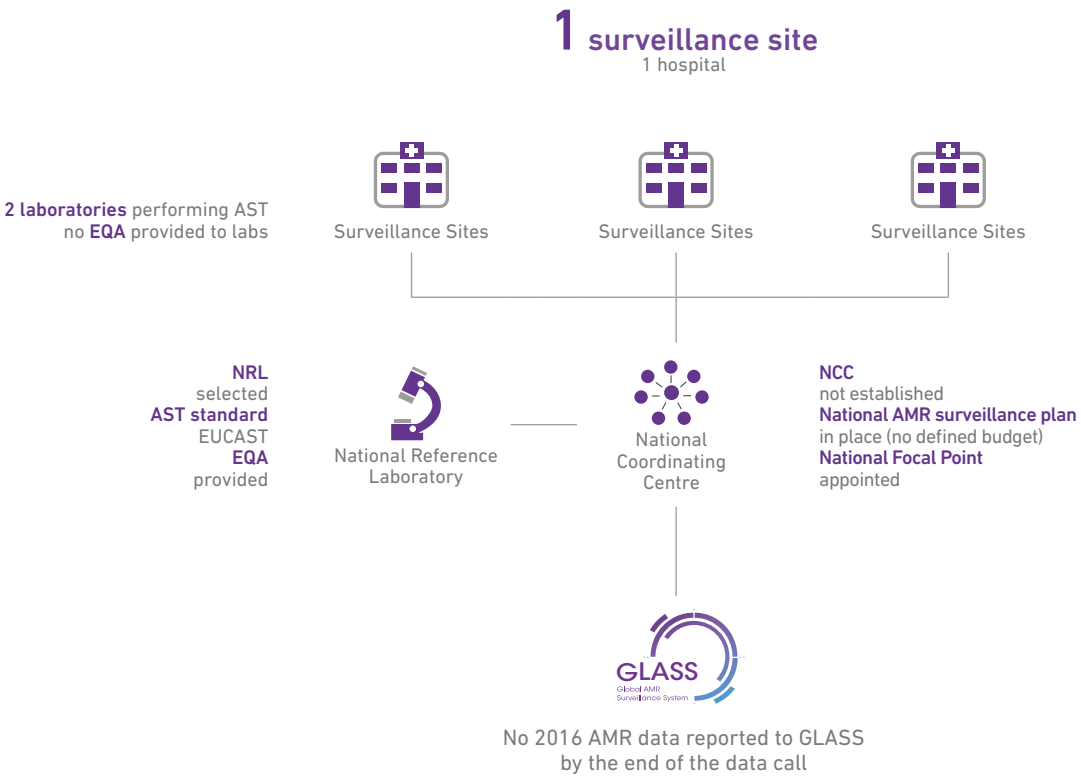


# Mozambique

## Population[1] 28.01 million

Mozambique is developing its National Action Plan on AMR and is building a national AMR surveillance system. Mozambique has been enrolled in GLASS since July 2017.

### Current status of the national AMR surveillance system



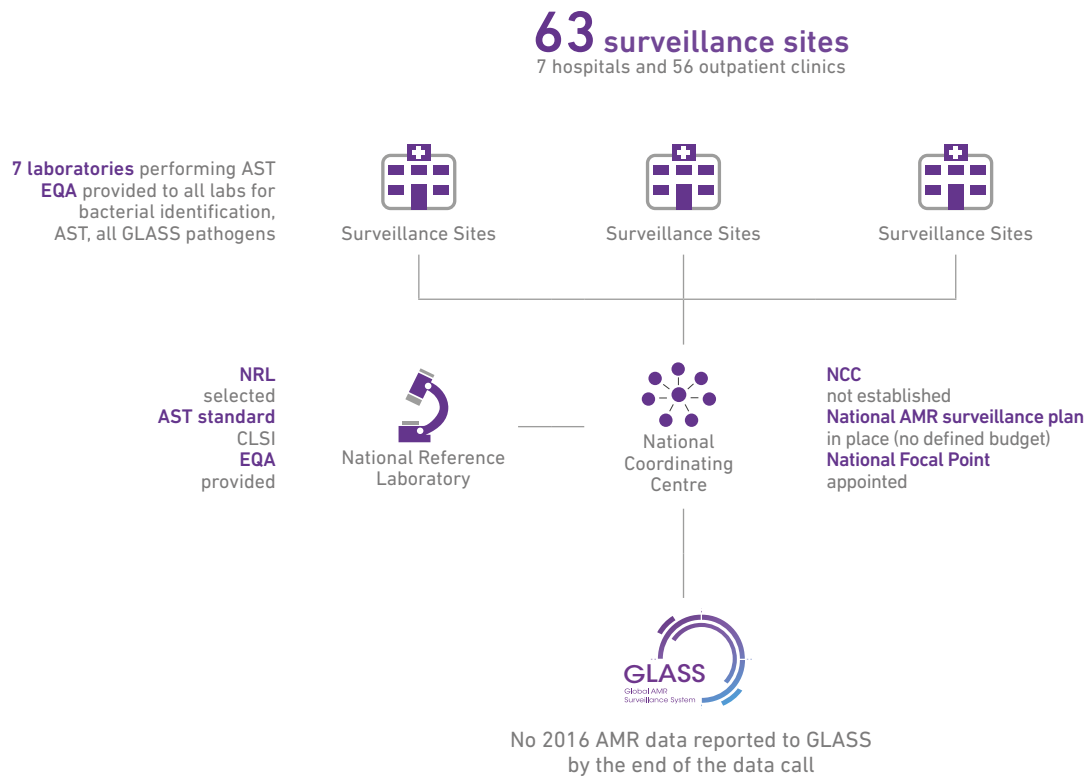

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Nigeria

## Population[1] 181.82 million

Nigeria is completing development of the National Action Plan on AMR and building its national AMR surveillance system coordinated by the Nigeria Centre for Disease Control. Nigeria has been enrolled in GLASS since April 2017.

## Current status of the national AMR surveillance system



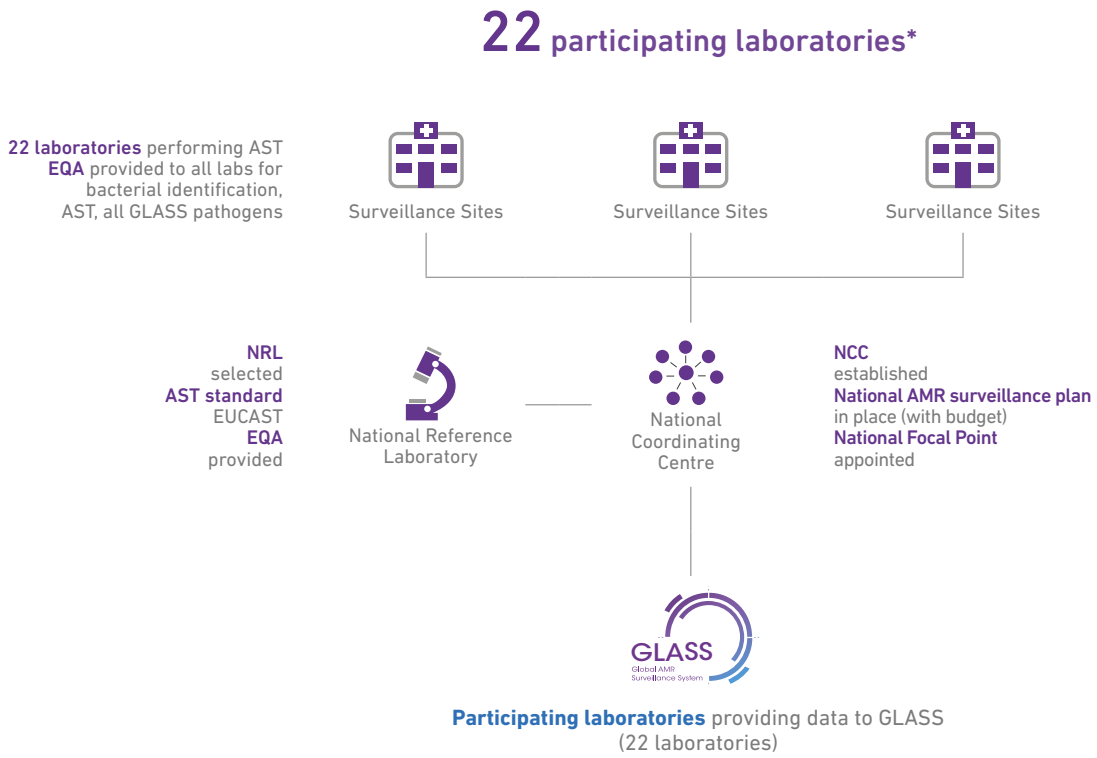

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Norway

## Population[1] 5.20 million

The Norwegian Surveillance System for Antimicrobial Drug Resistance (NORM) was established in 2000. In 2015 Norway adopted the National Strategy against Antibiotic Resistance 2015-2020. The country participates in the EARS-NET and has been enrolled in GLASS since September 2016.

## Current status of the national AMR surveillance system




*The identification of the total number of surveillance sites submitting specimens to participating laboratories was not possible due to the set up of the national surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | ● | *Acinetobacter* spp. | ● | ● | ● | ● |
| | | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| | | *Salmonella* spp. | ● | ● | ● | ● |
| | | *S. aureus* | ● | ● | ● | ● |
| | | *S. pneumoniae* | ● | ● | ● | ● |
| URINE | ● | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| STOOL | ● | *Salmonella* spp. | ● | ● | ● | ● |
| | | *Shigella* spp. | ● | ● | ● | ● |
| GENITAL | ● | *N. gonorrhoeae* | ● | ● | ● | ● |

● 100% data collected ● 99-70% data collected ● <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Norway

## Population 5.20 million

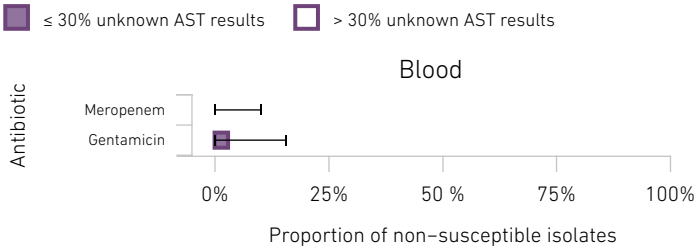
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | 9 | 24 | - |
| | | | | *E. coli* | 732 | 2 879 | - |
| | | | | *K. pneumoniae* | 161 | 648 | - |
| | | | | *Salmonella* spp. | - | - | 66 |
| | | | | *S. aureus* | 312 | 1 197 | - |
| | | | | *S. pneumoniae* | 94 | 402 | - |
| URINE | - | - | - | *E. coli* | - | - | 1 621 |
| | | | | *K. pneumoniae* | - | - | 813 |
| STOOL | - | - | - | *Salmonella* spp. | - | - | 786 |
| | | | | *Shigella* spp. | - | - | 82 |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | 276 |

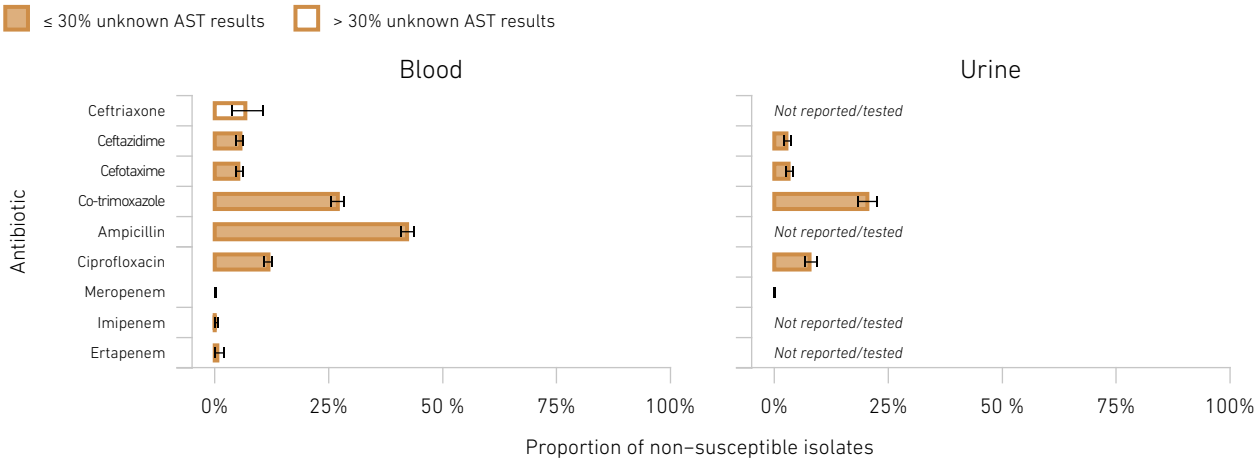
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Acinetobacter* spp.




### *Escherichia coli*

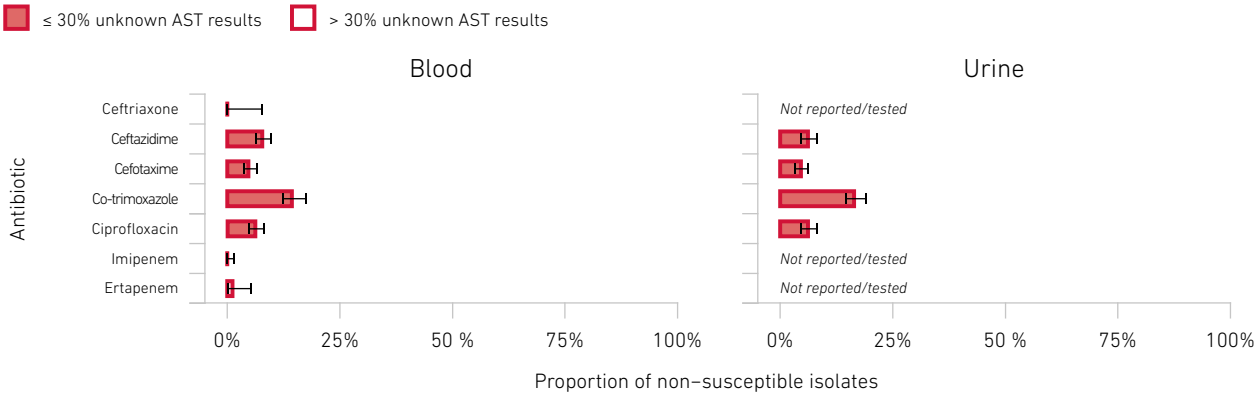



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

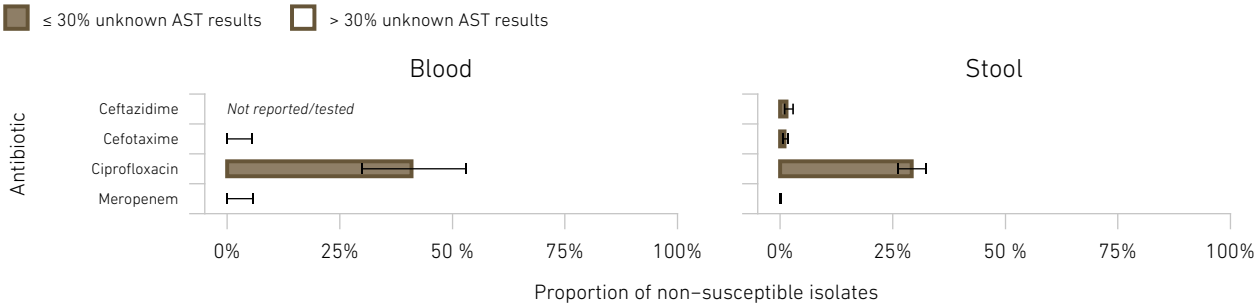
# Norway

## Population 5.20 million

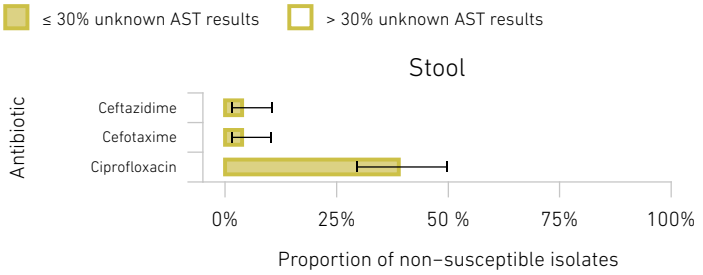
### *Klebsiella pneumoniae*



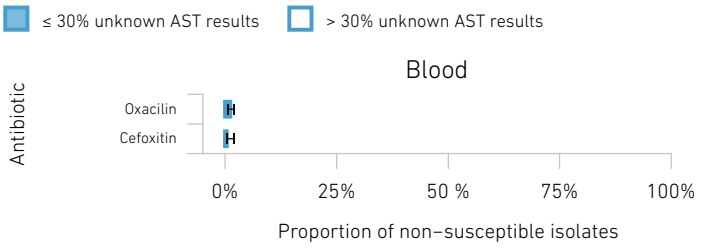

### *Salmonella* spp.




### *Shigella* spp.



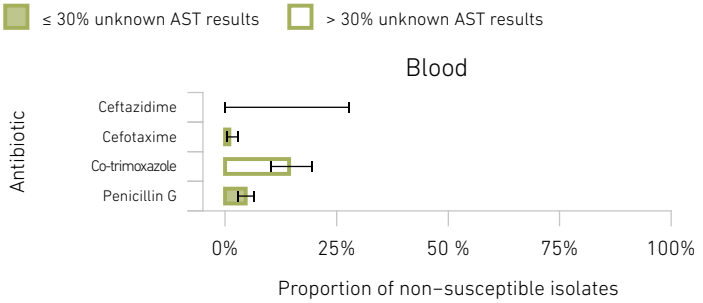

### *Staphylococcus aureus*



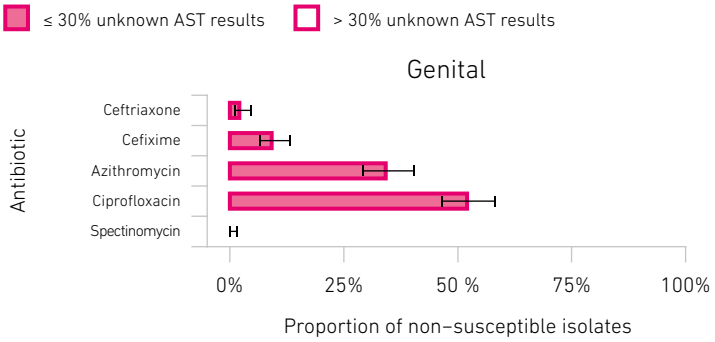
# Norway

## Population 5.20 million

### *Streptococcus pneumoniae*




### *Neisseria gonorrhoeae*



# Oman

## Population[1] 4.20 million

Oman has approved its National Policy and Action Plan on AMR and has been enrolled in GLASS since May 2016.

## Current status of the national AMR surveillance system

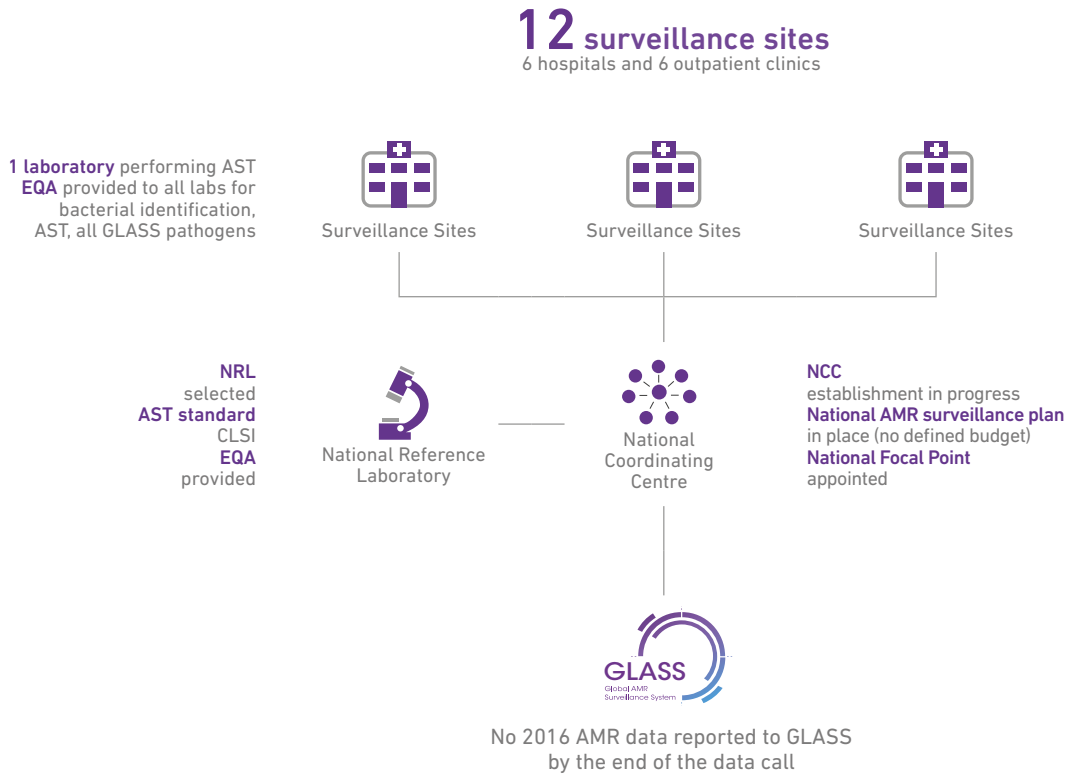

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Pakistan

## Population[1] 189.38 million

AMR surveillance has been conducted in Pakistan by the Antimicrobial Resistance Network (PARN) set up in March 2007. Pakistan is finalizing development of a National Action Plan on AMR and is building its national AMR surveillance system. Pakistan has been enrolled in GLASS since June 2017.

## Current status of the national AMR surveillance system



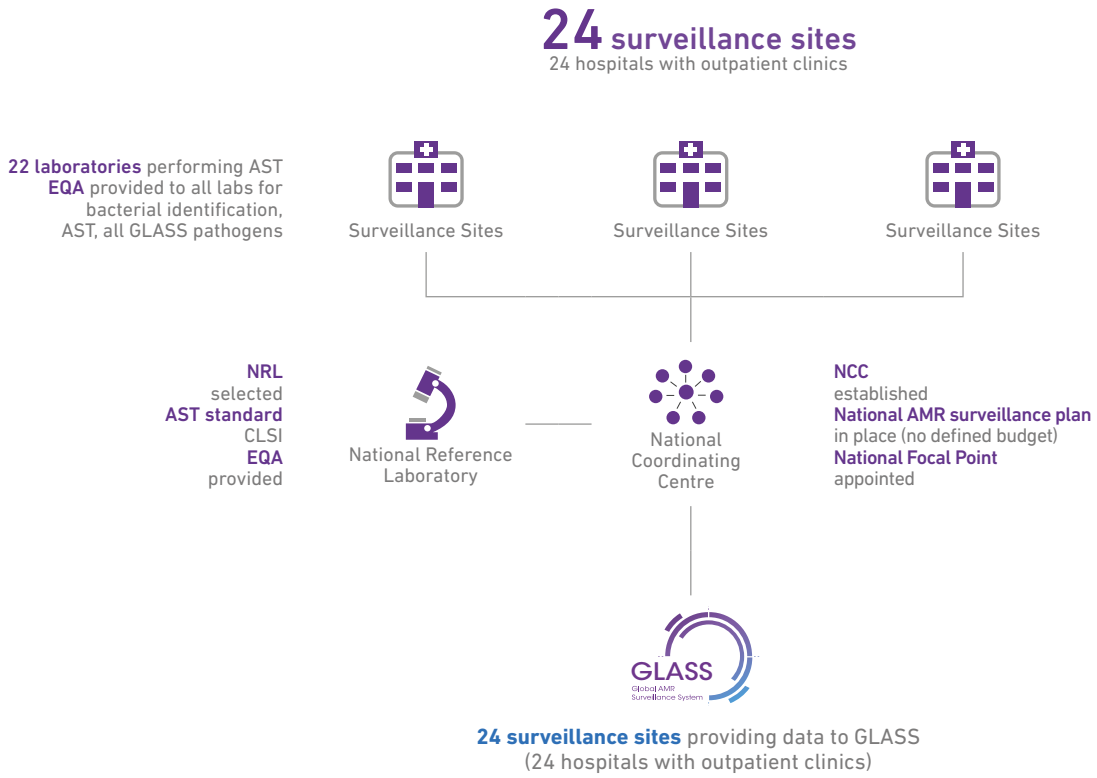

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Philippines

## Population[1] 101.71 million

The National Action Plan to Combat Antimicrobial Resistance: One Health Approach has been launched in 2015 and describes the country's strategies to control emergence of AMR for the next 5 years. The Philippine Antimicrobial Resistance Surveillance Program produces annual reports on AMR surveillance since 1988. Philippines have been enrolled in GLASS since June 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟠 | 🟠 | 🟠 |
| | | *E. coli* | 🟢 | 🟠 | 🟠 | 🟠 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟢 | 🟠 |
| | | *Salmonella* spp. | 🟢 | 🟠 | 🟠 | 🟠 |
| | | *S. aureus* | 🟢 | 🟠 | 🟠 | 🟠 |
| | | *S. pneumoniae* | 🟢 | 🟠 | 🟢 | 🟠 |
| URINE | 🔴 | *E. coli* | 🟢 | 🟠 | 🟠 | 🟠 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟠 | 🟠 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🟢 | 🟠 | 🟠 |
| | | *Shigella* spp. | 🟢 | 🟢 | 🟢 | 🟠 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🟢 | 🟠 | 🟠 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Philippines

## Population 101.71 million

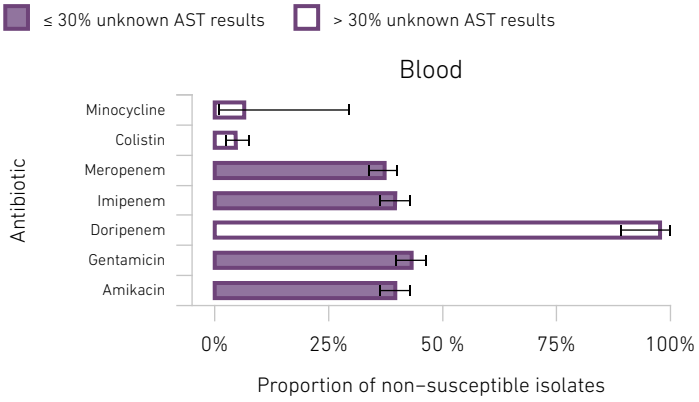
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | - | *Acinetobacter* spp. | 430 | 265 | 240 |
| | | | | *E. coli* | 623 | 139 | 280 |
| | | | | *K. pneumoniae* | 421 | 312 | 304 |
| | | | | *Salmonella* spp. | 202 | 39 | 57 |
| | | | | *S. aureus* | 756 | 164 | 264 |
| | | | | *S. pneumoniae* | 125 | 9 | 5 |
| **URINE** | - | - | - | *E. coli* | 3 282 | 690 | 862 |
| | | | | *K. pneumoniae* | 893 | 383 | 415 |
| **STOOL** | - | - | - | *Salmonella* spp. | 26 | 15 | 8 |
| | | | | *Shigella* spp. | 7 | 3 | 3 |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | 163 | - | 2 |

## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**

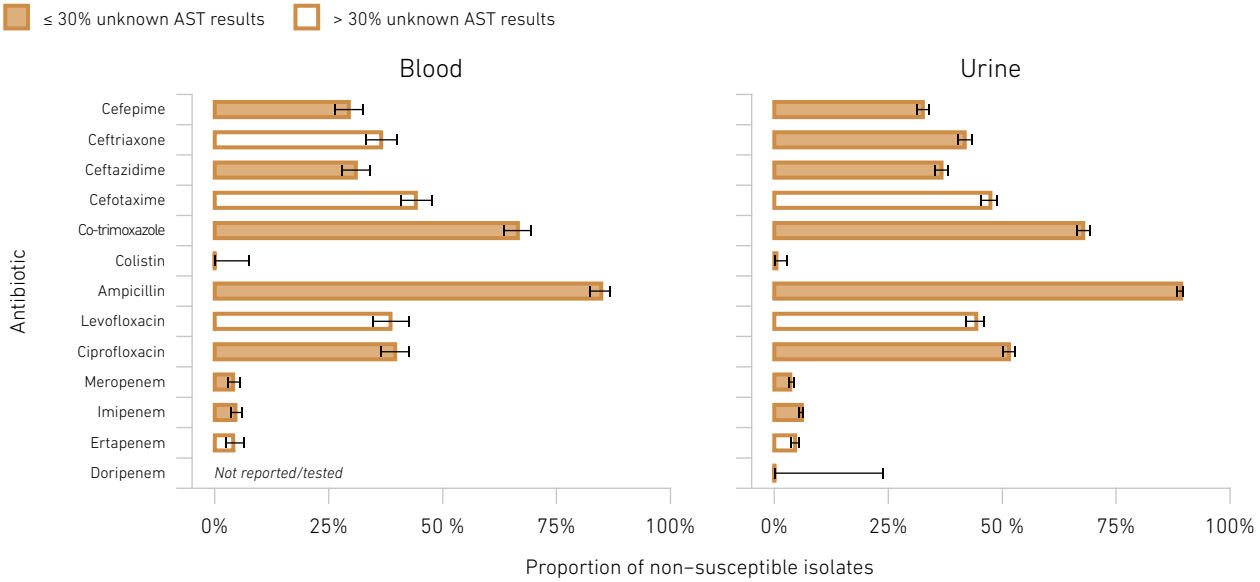



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

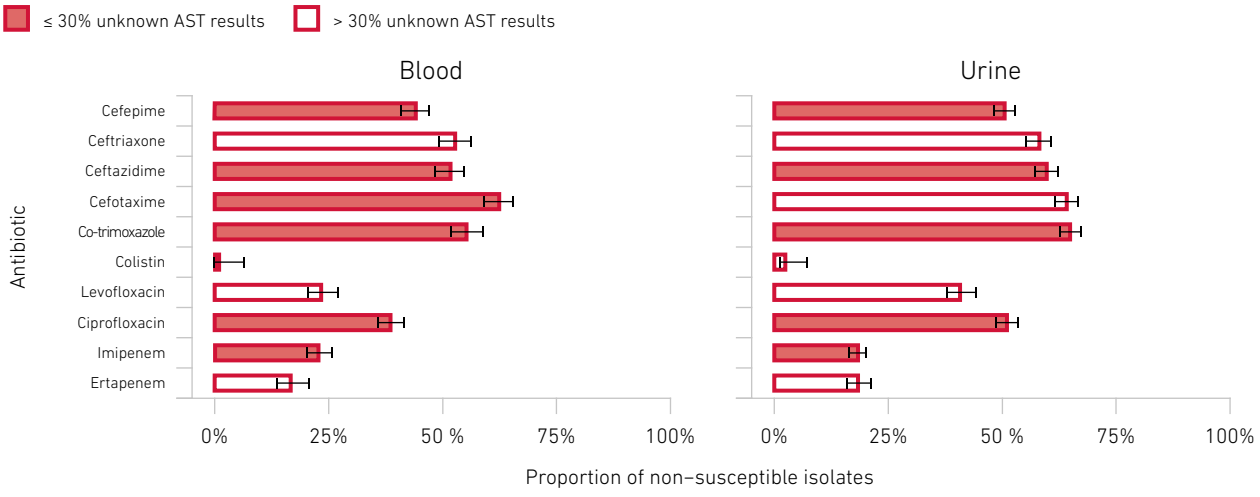
# Philippines

## Population 101.71 million

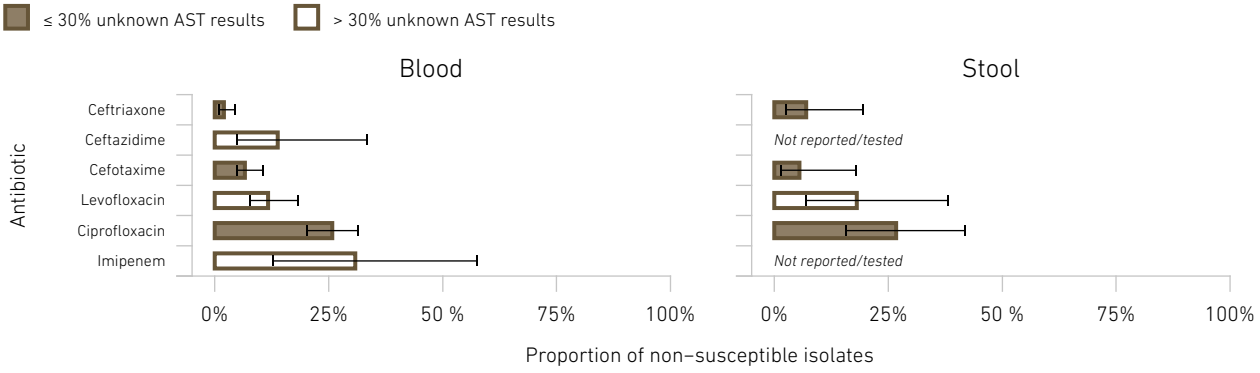
### *Escherichia coli*




### *Klebsiella pneumoniae*



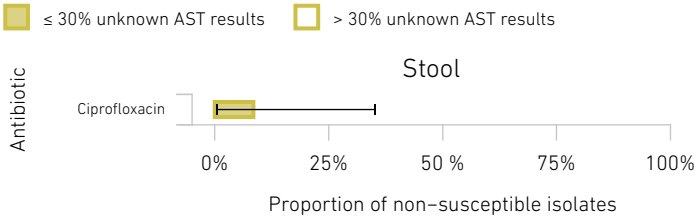

### *Salmonella* spp.



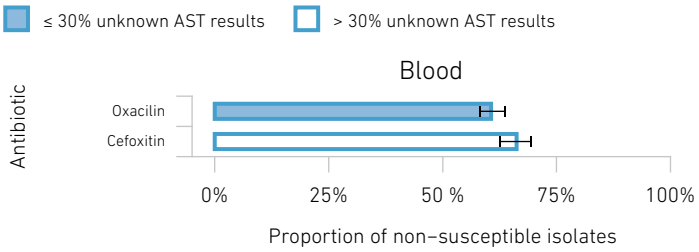
# Philippines

## Population 101.71 million

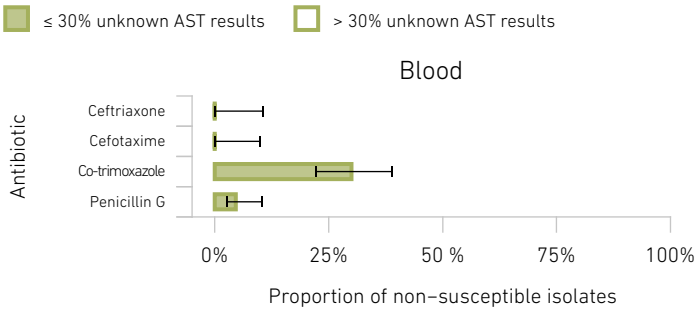
### *Shigella* spp.



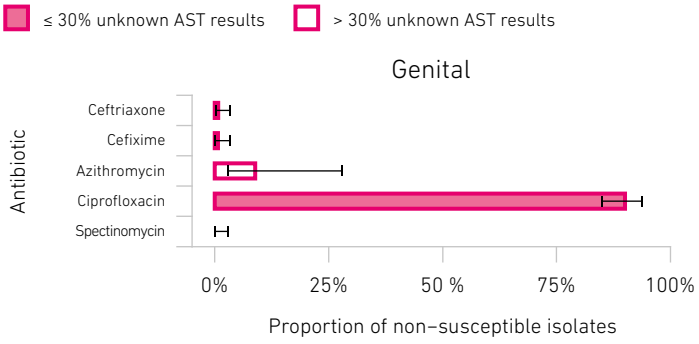

### *Staphylococcus aureus*




### *Streptococcus pneumoniae*




### *Neisseria gonorrhoeae*

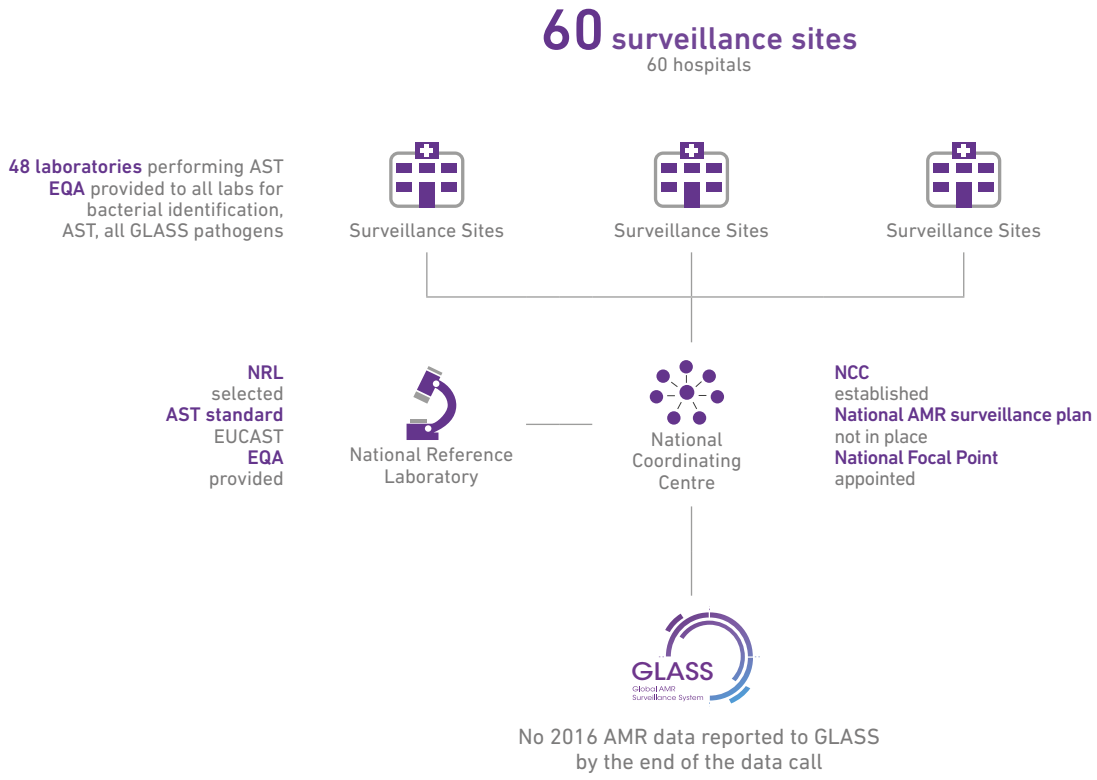


# Poland

## Population[1] 38.26 million

Poland is implementing a National Action Plan on AMR and has a national AMR surveillance system. The country participates in the EARS-NET and has been enrolled in GLASS since August 2016.

## Current status of the national AMR surveillance system



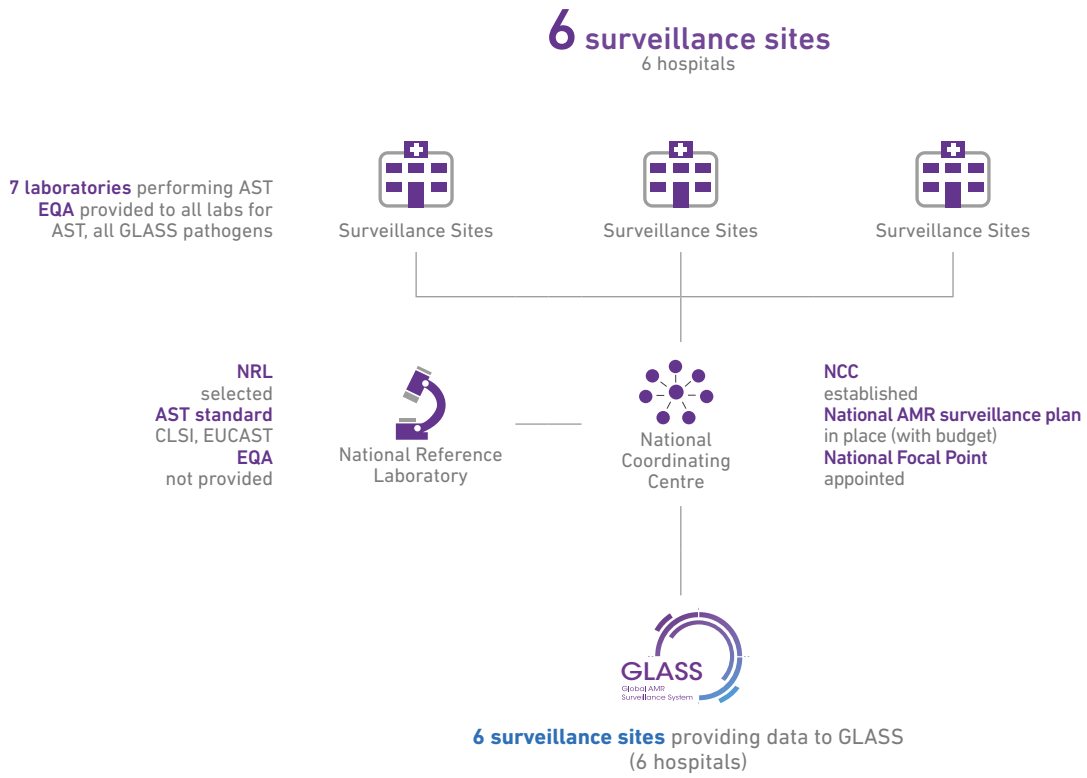

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Republic of Korea

## Population[1] 50.60 million

The Republic of Korea has been conducting surveillance of AMR since 2002 when the first nationwide AMR surveillance system (Korean Antimicrobial Resistance Monitoring System, KARMS) was launched. After adopting the National Action Plan on AMR in 2016, the national system was reorganized and named Kor-GLASS. The Republic of Korea has enrolled in GLASS in July 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | ● | *Acinetobacter* spp. | ● | ● | ● | ● |
| | | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| | | *Salmonella* spp. | ● | ● | ● | ● |
| | | *S. aureus* | ● | ● | ● | ● |
| | | *S. pneumoniae* | ● | ● | ● | ● |
| URINE | ● | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| STOOL | ● | *Salmonella* spp. | ● | ● | ● | ● |
| | | *Shigella* spp.* | ● | ● | ● | ● |
| GENITAL | ● | *N. gonorrhoeae* | ● | ● | ● | ● |

● 100% data collected ● 99-70% data collected ● <70% data collected

* Data collected by the national system, but no positive samples were obtained.

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Republic of Korea

## Population 50.60 million

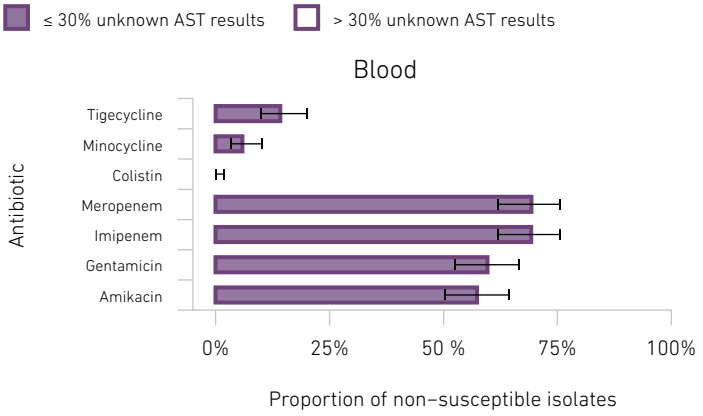
## Data overview - collection between January and June 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | 38 938 | 9 434 | - | *Acinetobacter* spp. | 27 | 142 | - |
| | | | | *E. coli* | 885 | 219 | - |
| | | | | *K. pneumoniae* | 306 | 116 | - |
| | | | | *Salmonella* spp. | 32 | 2 | - |
| | | | | *S. aureus* | 195 | 195 | - |
| | | | | *S. pneumoniae* | 11 | 3 | - |
| **URINE** | 31 426 | 8 988 | - | *E. coli* | 3 637 | 799 | - |
| | | | | *K. pneumoniae* | 491 | 321 | - |
| **STOOL** | 4 777 | 4 283 | - | *Salmonella* spp. | 65 | 6 | - |
| | | | | *Shigella* spp. | - | - | - |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | - | - | - |

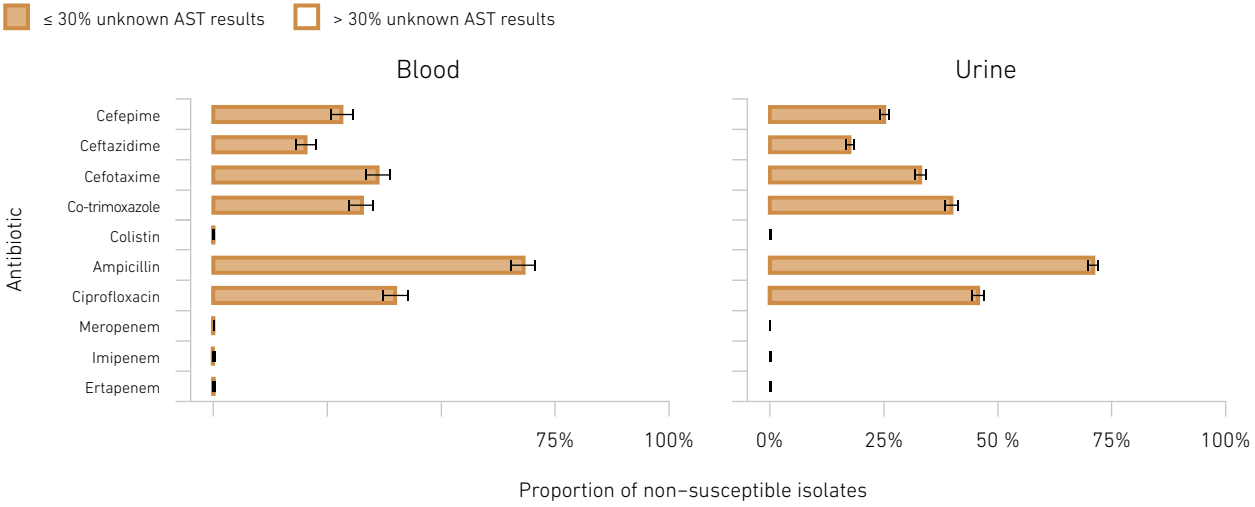
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**




***Escherichia coli***

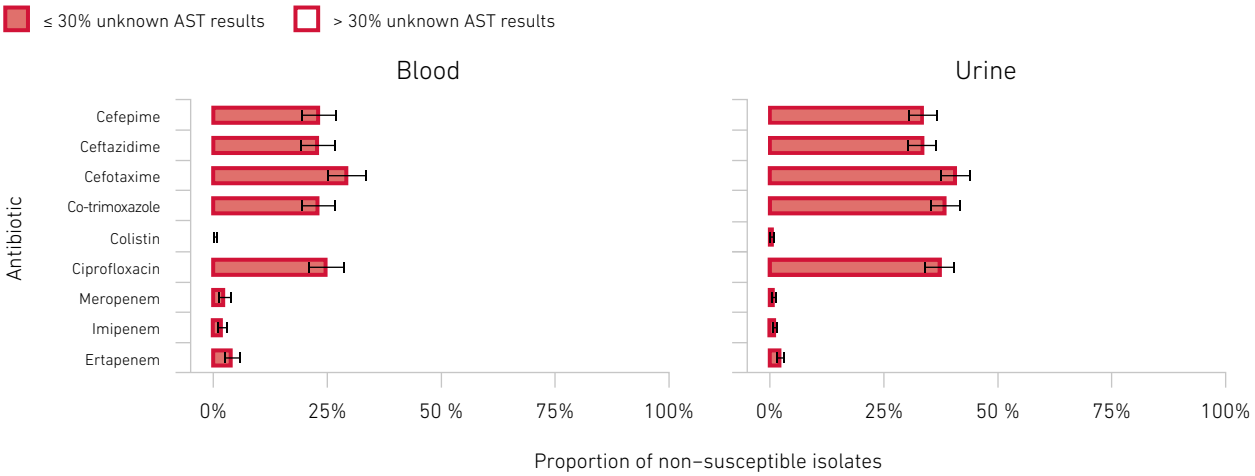



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

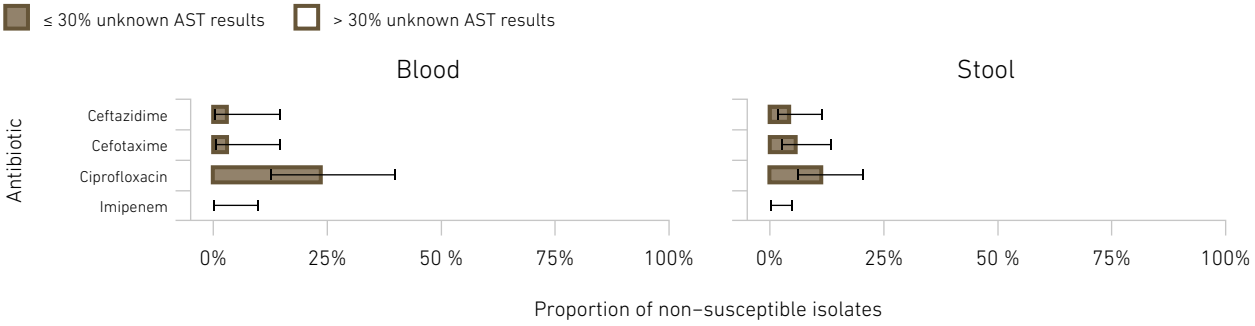
# Republic of Korea

## Population 50.60 million

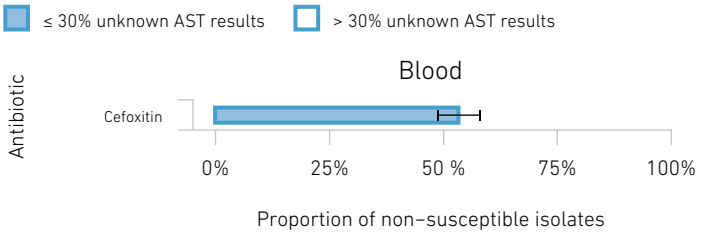
### *Klebsiella pneumoniae*



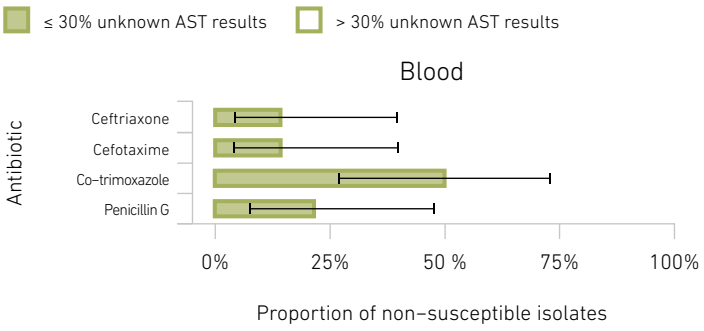

### *Salmonella* spp.




### *Staphylococcus aureus*




### *Streptococcus pneumoniae*



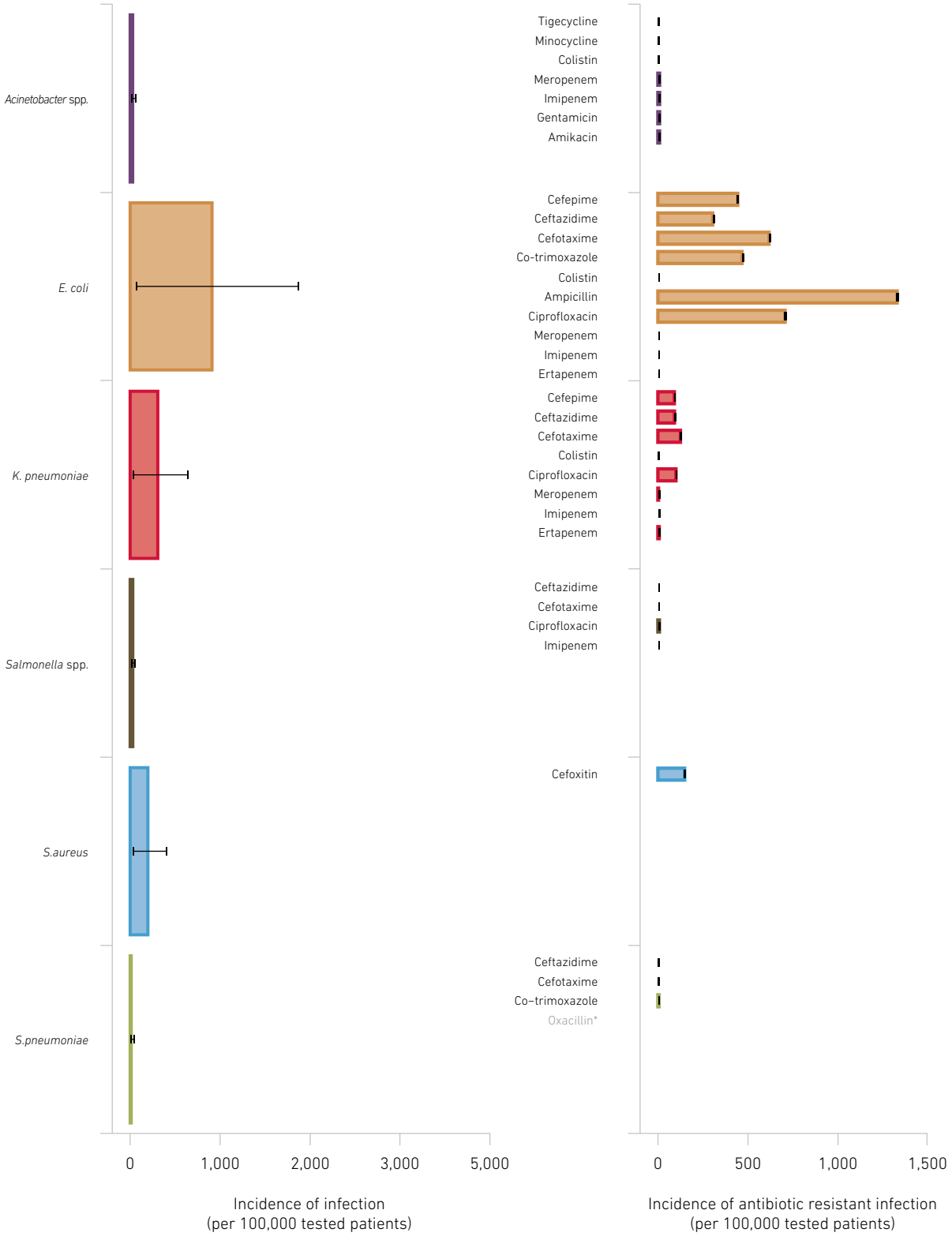
# Republic of Korea

## Population 50.60 million

### Non-susceptible pathogen – antimicrobial combination frequency

Incidence of infection caused by pathogens under surveillance, per specimen and infection origin (left).
Incidence of infection caused by pathogens non-susceptible to defined antibiotics under surveillance, per specimen and infection origin (right).

**Blood – Community infection origin** (n tested = 38938)

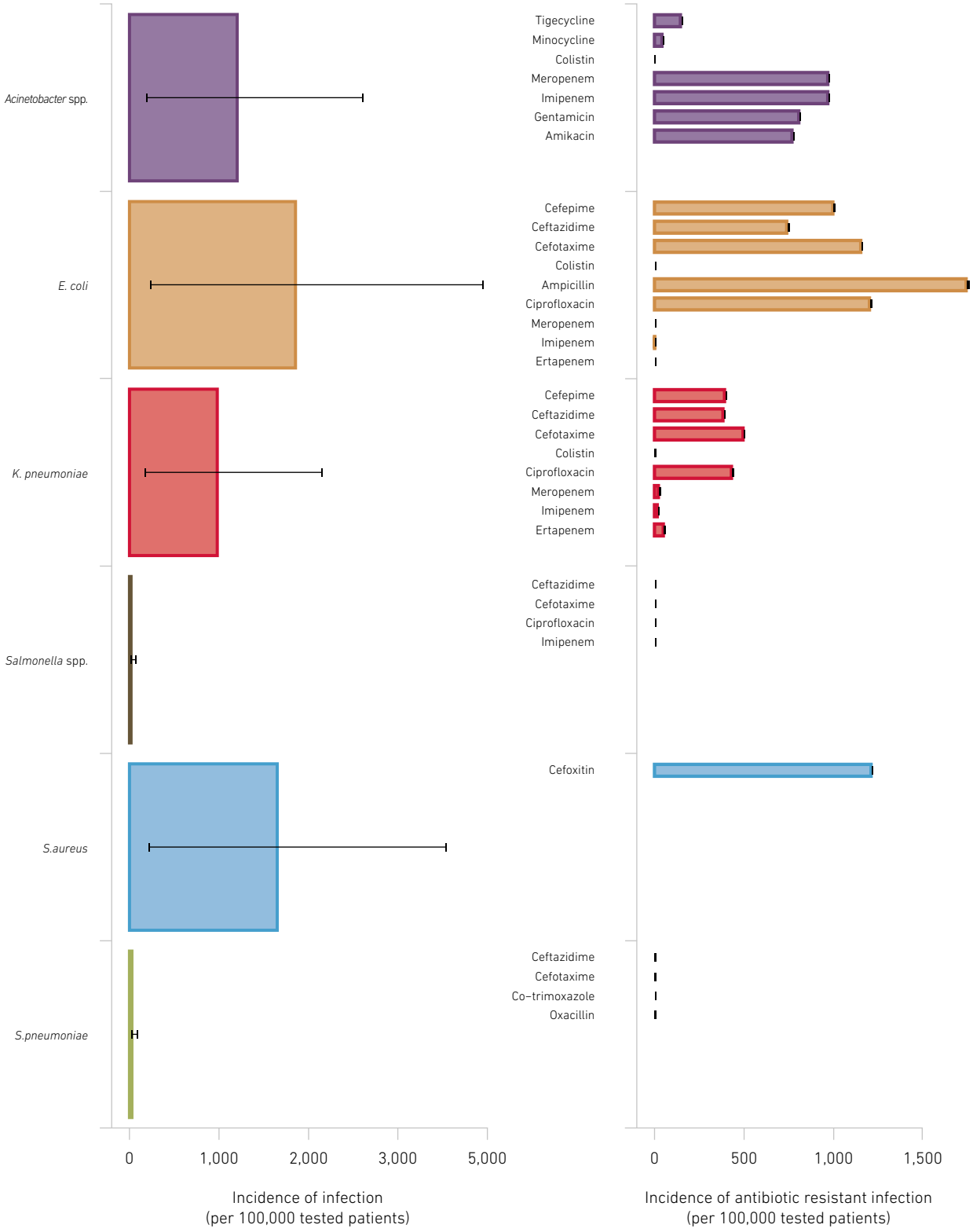



*Antibiotic with >30% unknown AST results – AMR rates not shown

# Republic of Korea

## Population 50.60 million

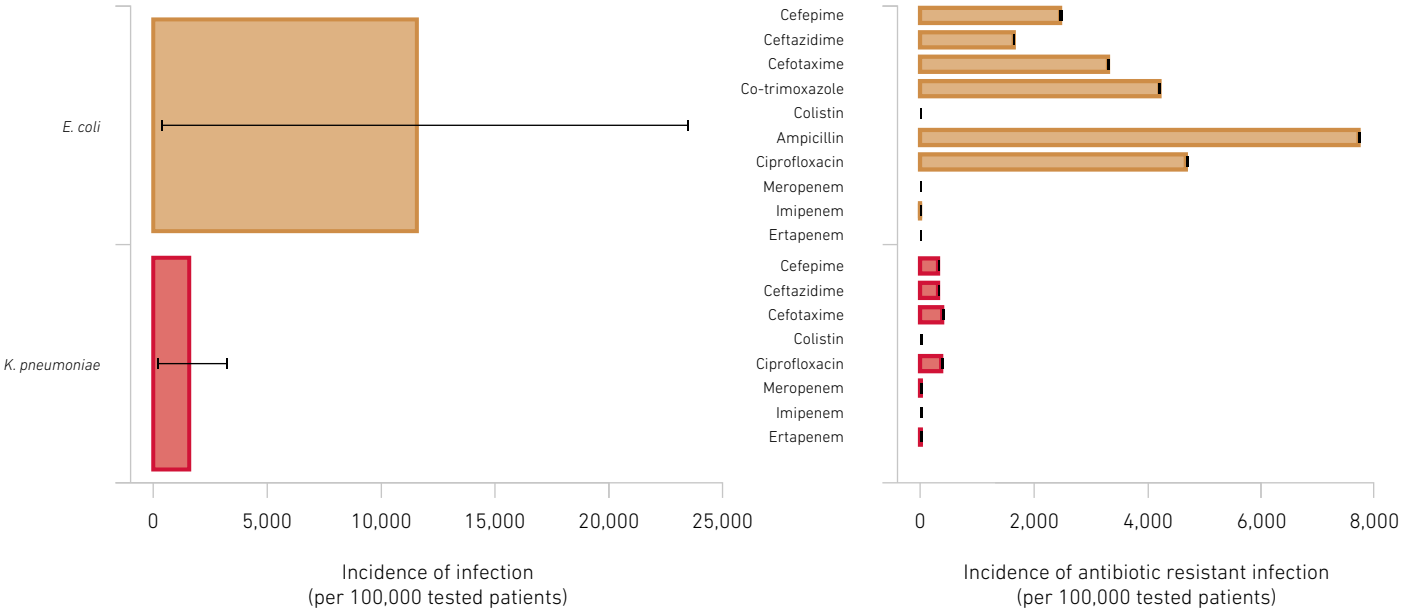
**Blood – Hospital infection origin**



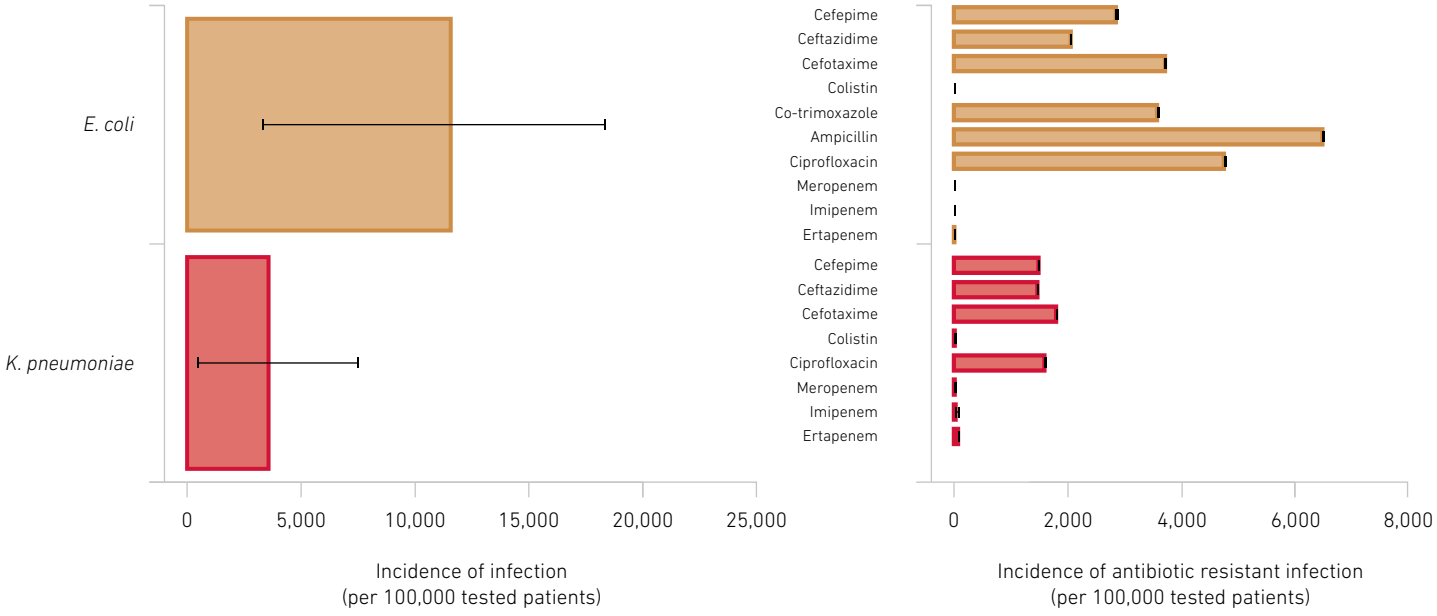
# Republic of Korea

## Population 50.60 million

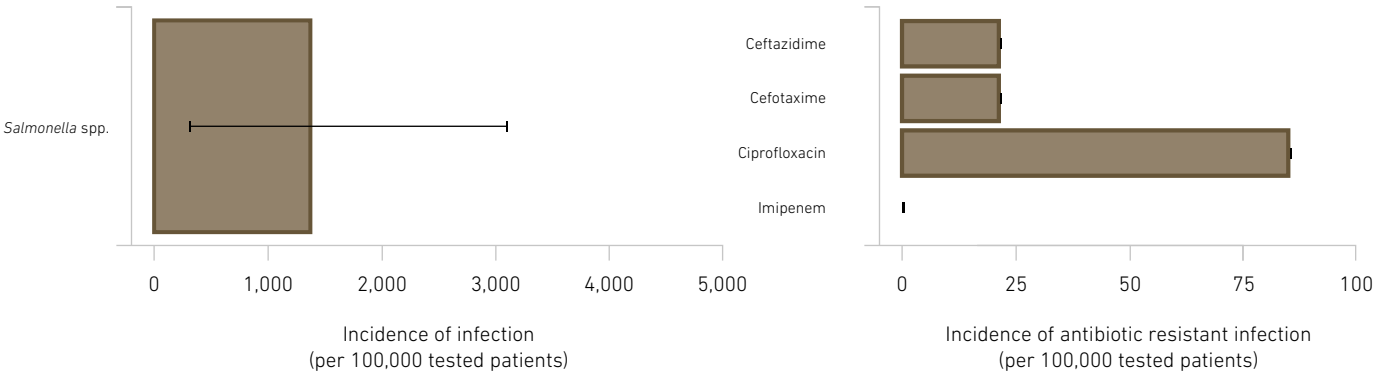
**Urine – Community infection origin** (n tested = 31426)




**Urine – Hospital infection origin** (n tested = 8988)



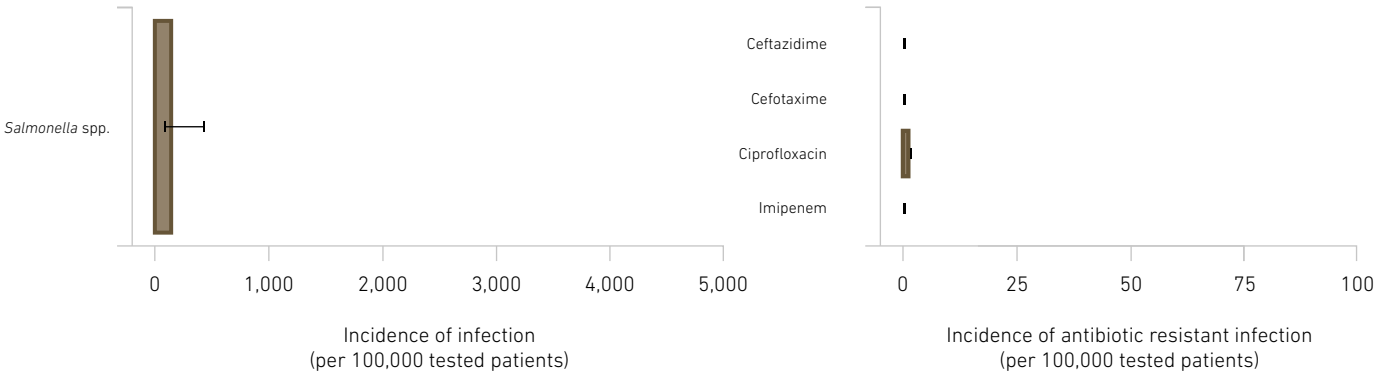

**Stool – Community infection origin** (n tested = 4777)



# Republic of Korea

## Population 50.60 million

**Stool – Hospital infection origin** (n tested = 4283)

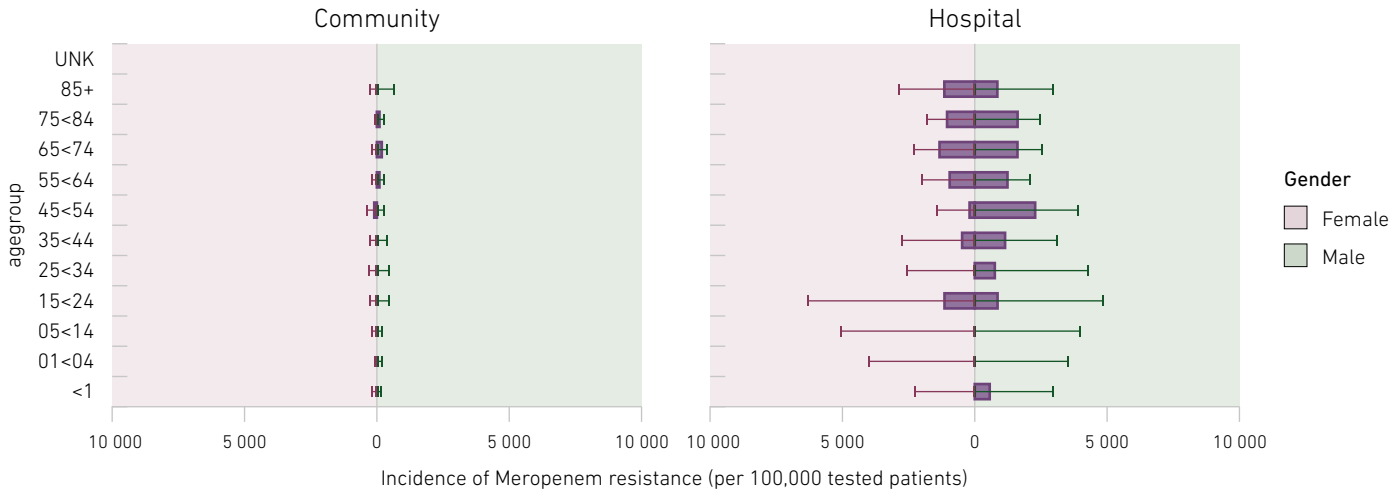



## Non-susceptible pathogen-meropenem[2] combination stratified incidence[2]

Incidence of infection caused by pathogens non-susceptible to meropenem per specimen and infection origin (right), stratified by age and gender.

**Blood**

***Acinetobacter baumannii***




***Escherichia coli***

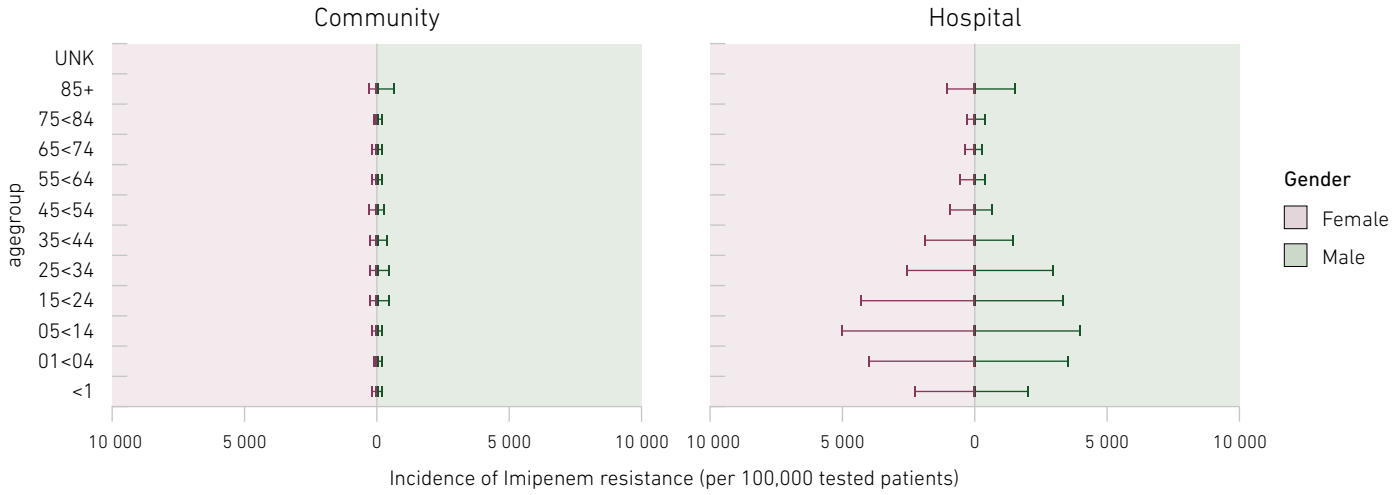

2. Results for isolates with >30% unknown AST results are not shown. Grouping of carbapenem antibiotics was not possible due to results bias generation linked with data aggregation.

# Republic of Korea

## Population 50.60 million

***Klebsiella pneumoniae***

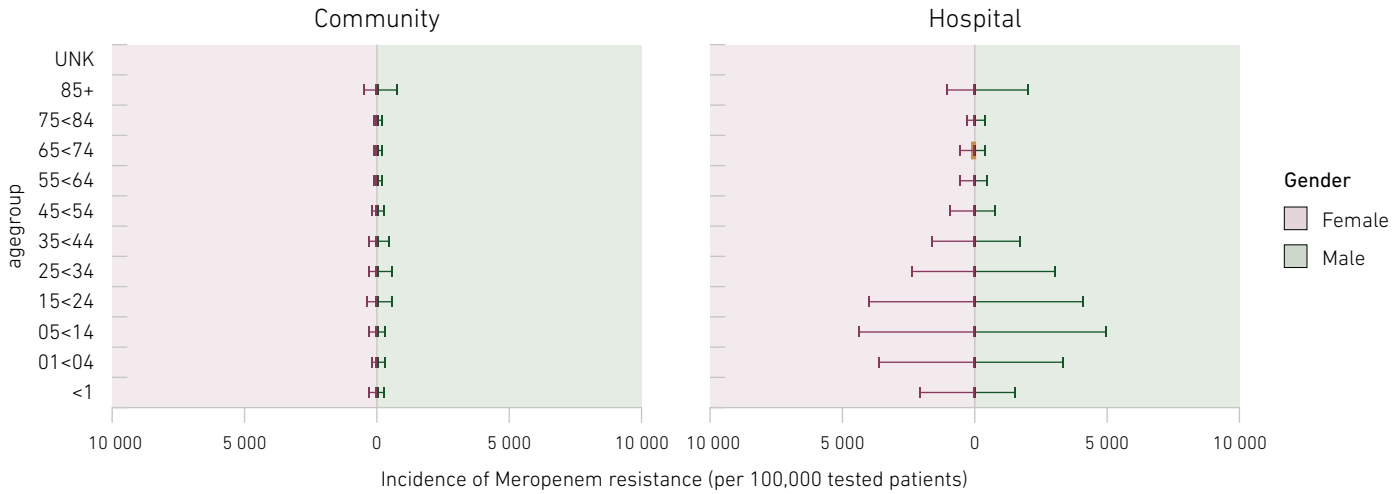

***Salmonella* spp.***




*Data on Imipenem presented because no testing was done for Meropenem

**Urine**

***Escherichia coli***



# Republic of Korea

## Population 50.60 million

***Klebsiella pneumoniae***


**Stool**
***Salmonella* spp.***

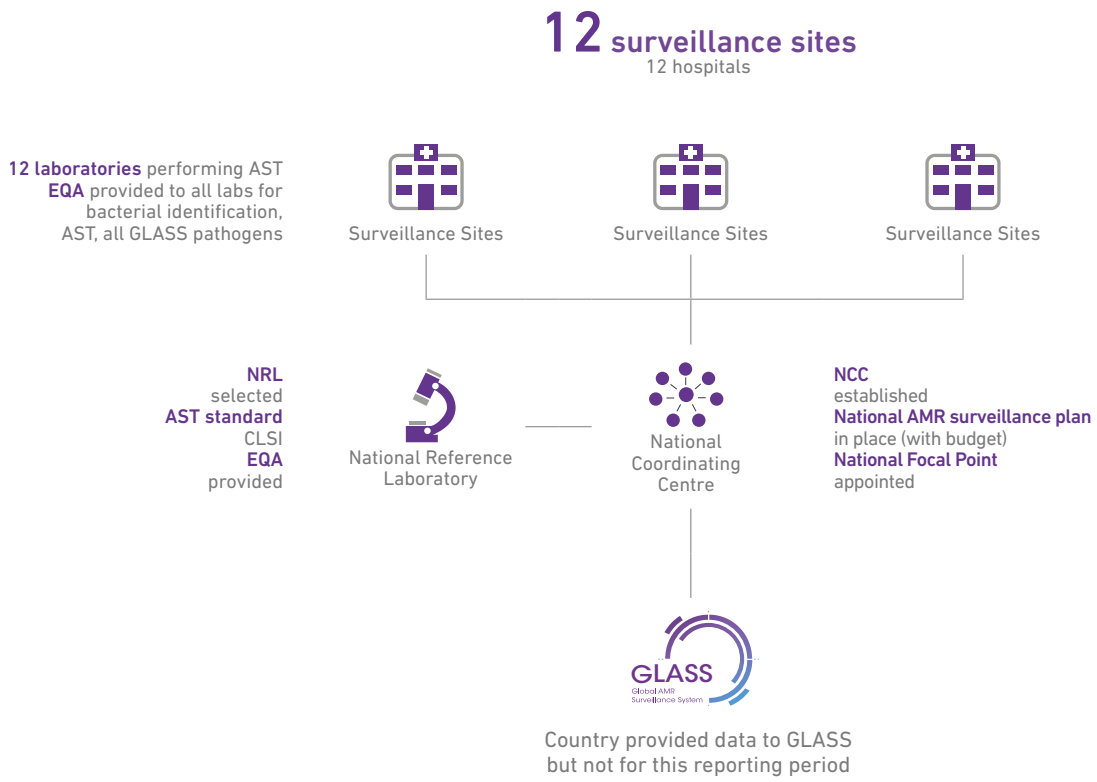

*Data on Imipenem presented because no testing was done for Meropenem

# Saudi Arabia

## Population[1] 31.55 million

Saudi Arabia is implementing a National Action Plan on AMR and developing a national AMR surveillance system. The country has been enrolled in GLASS since May 2017.

## Current status of the national AMR surveillance system



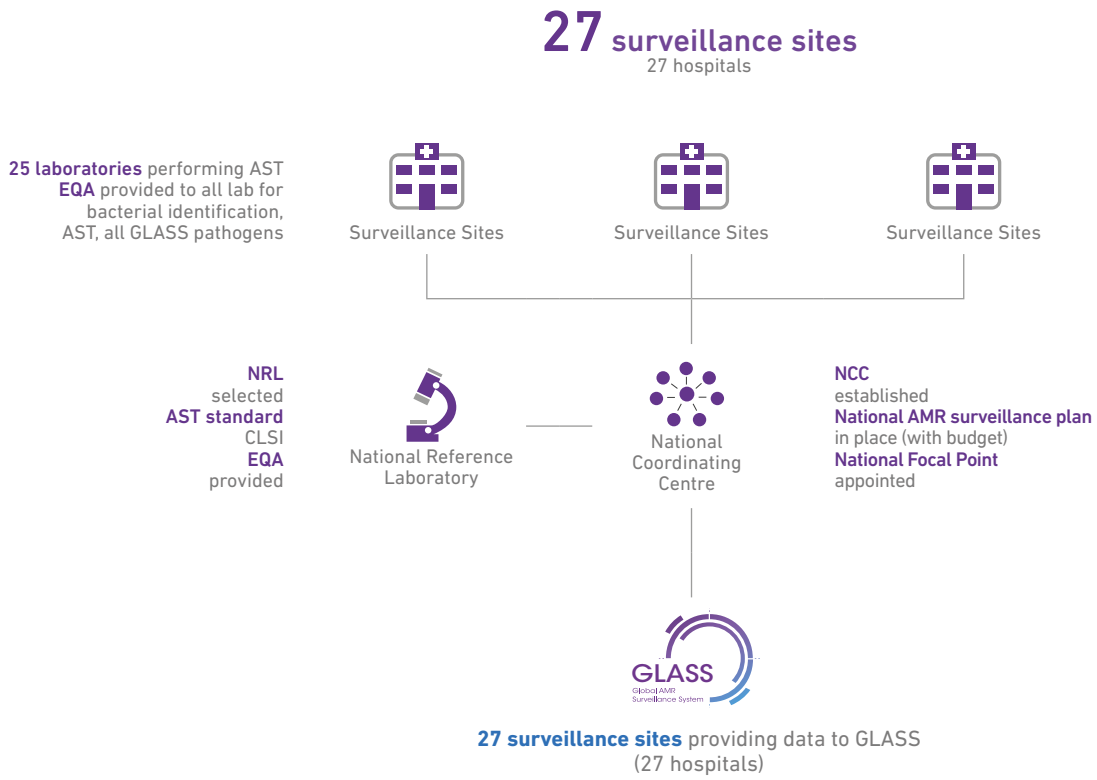

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# South Africa

## Population[1] 55.29 million

The national AMR surveillance network (GERMS-SA) is coordinated by the National Institute for Communicable Diseases (NICD). South Africa is implementing the Antimicrobial Resistance National Strategy Framework (2014–2024). The country has been enrolled in GLASS since June 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | ● | *Acinetobacter* spp. | ● | ● | ● | ● |
| | | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| | | *Salmonella* spp. | ● | ● | ● | ● |
| | | *S. aureus* | ● | ● | ● | ● |
| | | *S. pneumoniae* | ● | ● | ● | ● |
| URINE | ● | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| STOOL | ● | *Salmonella* spp. | ● | ● | ● | ● |
| | | *Shigella* spp. | ● | ● | ● | ● |
| GENITAL | ● | *N. gonorrhoeae* | ● | ● | ● | ● |

● 100% data collected ● 99-70% data collected ● <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# South Africa

## Population 55.29 million

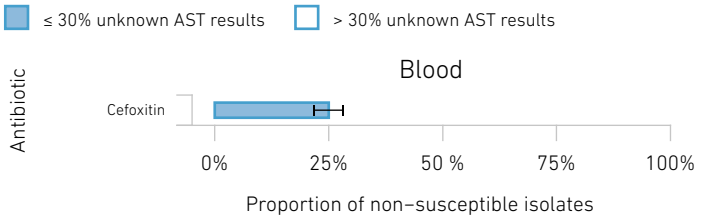
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | 371 | 156 | 144 155 | *Acinetobacter* spp. | - | - | - |
| | | | | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | 142 | 141 | 584 |
| | | | | *S. pneumoniae* | 230 | 16 | 401 |
| **URINE** | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| **STOOL** | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | - | - | - |

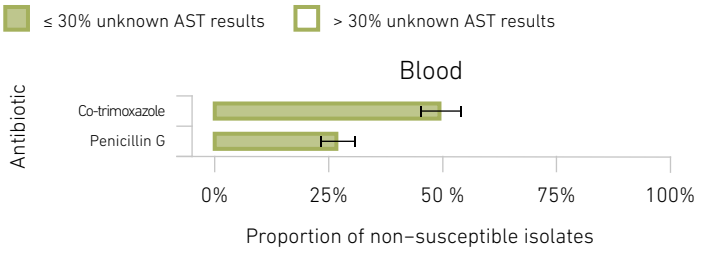
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Staphylococcus aureus***




***Streptococcus pneumonia***




2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

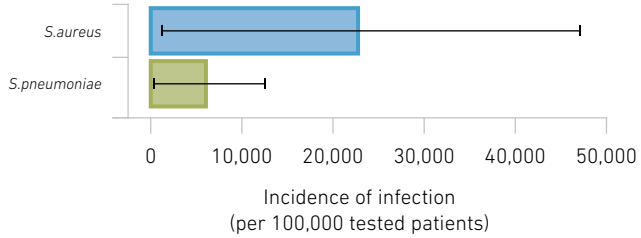
# South Africa

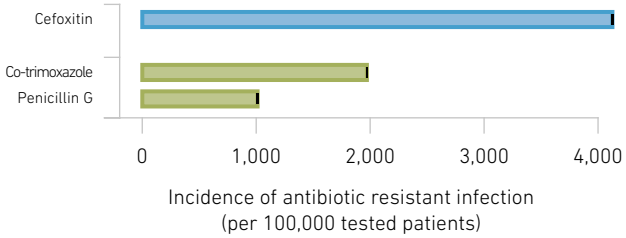
## Population 55.29 million

### Non-susceptible pathogen – antimicrobial combination frequency

Incidence of infection caused by pathogens under surveillance, per specimen and infection origin (left).
Incidence of infection caused by pathogens non-susceptible to defined antibiotics under surveillance, per specimen and infection origin (right).

**Blood – Unknown infection origin*** (Result for S. aureus are obtained from tested patients n tested = 38,110 - result for S. aureus are obtained from tested patients n tested = 106,572)



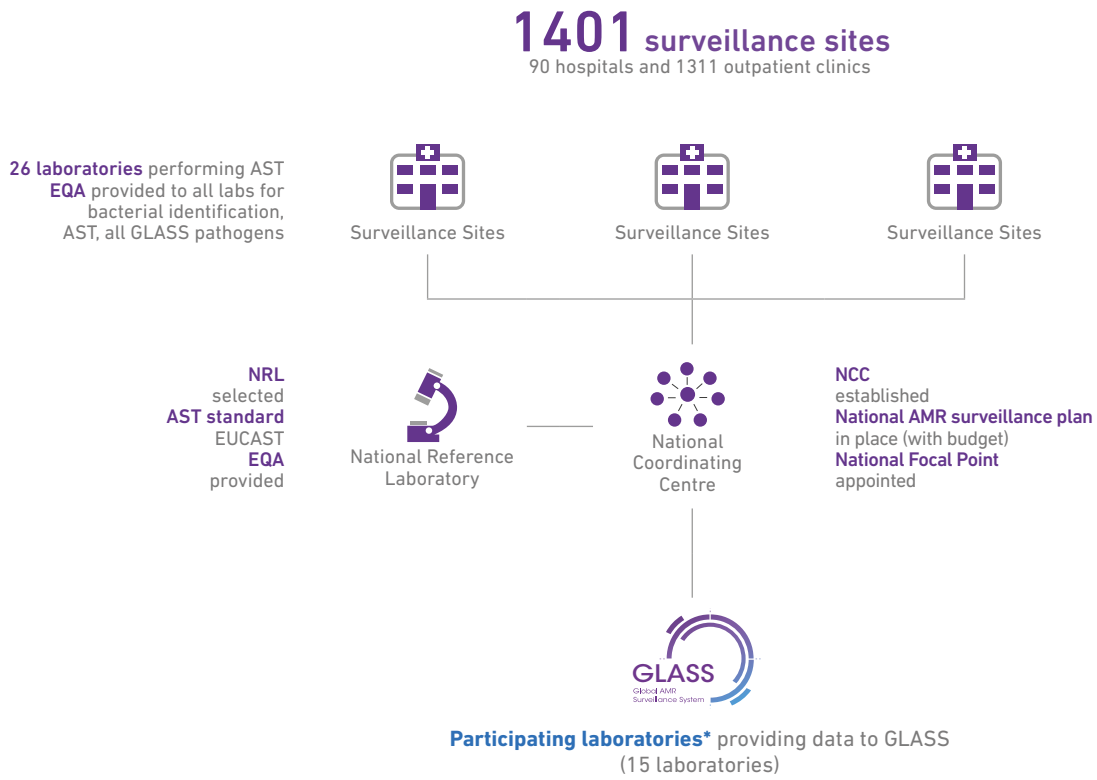

*when the proportion of provided information on infection origin is below 70%, results are not stratified.

# Sweden

## Population[1] 9.76 million

Sweden has been conducting surveillance of AMR since mid-1990s. The Public Health Agency of Sweden is coordinating the national surveillance of notifiable resistance as well as data from voluntary participation of the laboratories. Sweden participates in EARSnet since 1998. The Public Health Agency of Sweden and the National Veterinary Institute analyse and compile national data on antibiotic sales and resistance in an annual report, SWEDRES/SVARM (published in English). National strategies on antimicrobial resistance were released in 2000, 2006 and 2016. In 2017 a new revised AMR national action plan will be developed. Sweden has been enrolled in GLASS since 2016.

## Current status of the national AMR surveillance system




*The identification of the number of surveillance sites submitting specimens to the laboratorie reporting to GLASS was not possible due to the set up of the National surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | ● | *Acinetobacter* spp. | ● | ● | ● | ● |
| | | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| | | *Salmonella* spp. | ● | ● | ● | ● |
| | | *S. aureus* | ● | ● | ● | ● |
| | | *S. pneumoniae* | ● | ● | ● | ● |
| URINE | ● | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| STOOL | ● | *Salmonella* spp. | ● | ● | ● | ● |
| | | *Shigella* spp. | ● | ● | ● | ● |
| GENITAL | ● | *N. gonorrhoeae* | ● | ● | ● | ● |

● 100% data collected ● 99-70% data collected ● <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Sweden

## Population 9.76 million

## Data overview - collection between January and December 2016

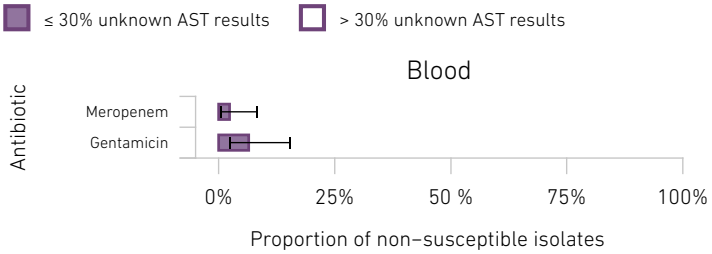
| Specimen | Number of tested patients | | | Pathogens | Number of isolates* | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | 86 |
| | | | | *E. coli* | - | - | 6 986 |
| | | | | *K. pneumoniae* | - | - | 1 514 |
| | | | | *Salmonella* spp. | - | - | 74 |
| | | | | *S. aureus* | - | - | 4511 |
| | | | | *S. pneumoniae* | - | - | 916 |
| URINE | - | - | - | *E. coli* | - | - | 131 172 |
| | | | | *K. pneumoniae* | - | - | 12 613 |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | 900 |

*data de-duplication not performed

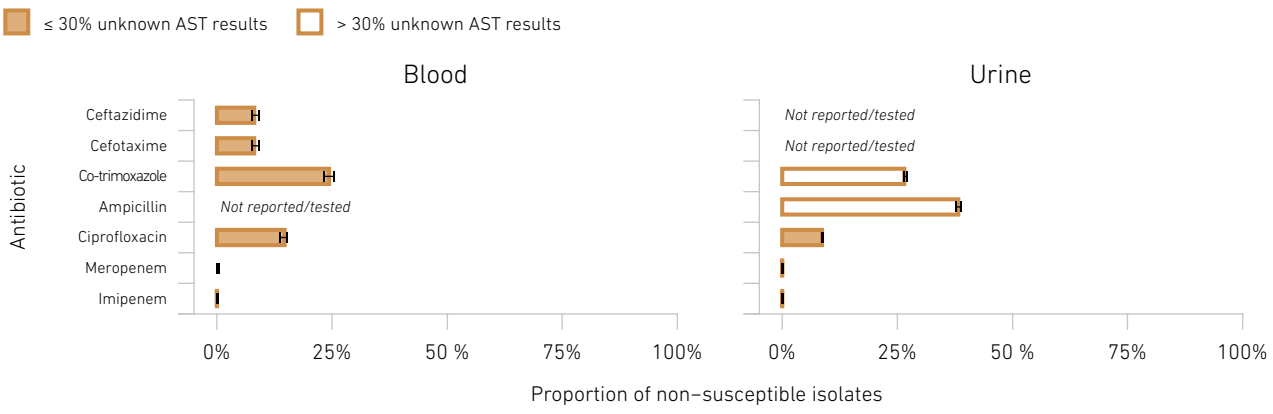
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Acinetobacter* spp.




### *Escherichia coli*

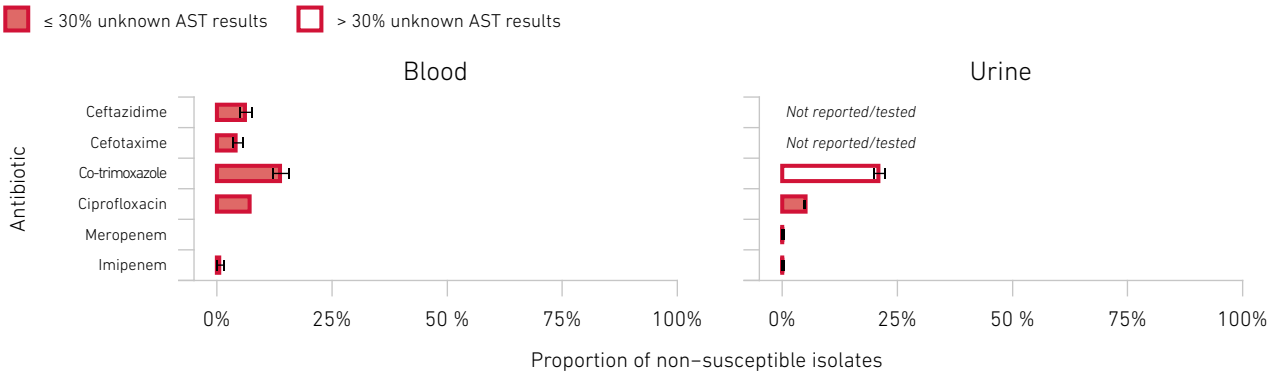



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

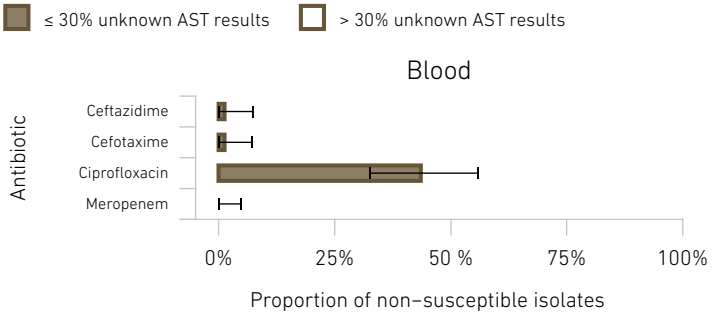
# Sweden

## Population 9.76 million

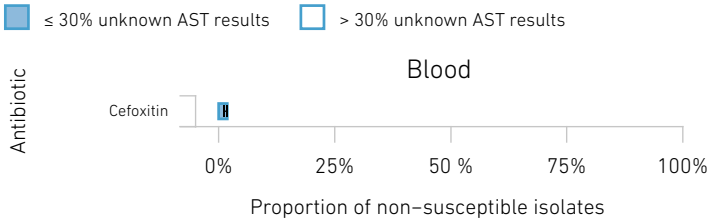
### *Klebsiella pneumoniae*



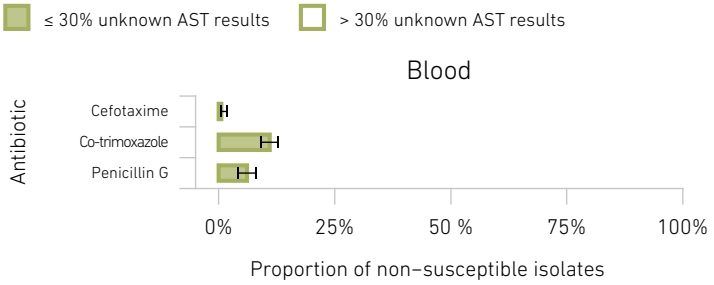

### *Salmonella* spp.



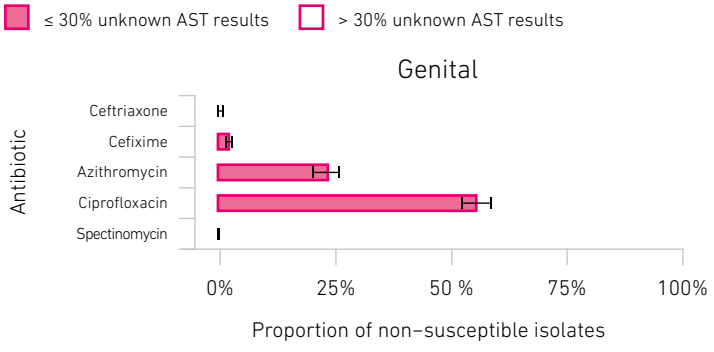

### *Staphylococcus aureus*




### *Streptococcus pneumoniae*




### *Neisseria gonorrhoeae*

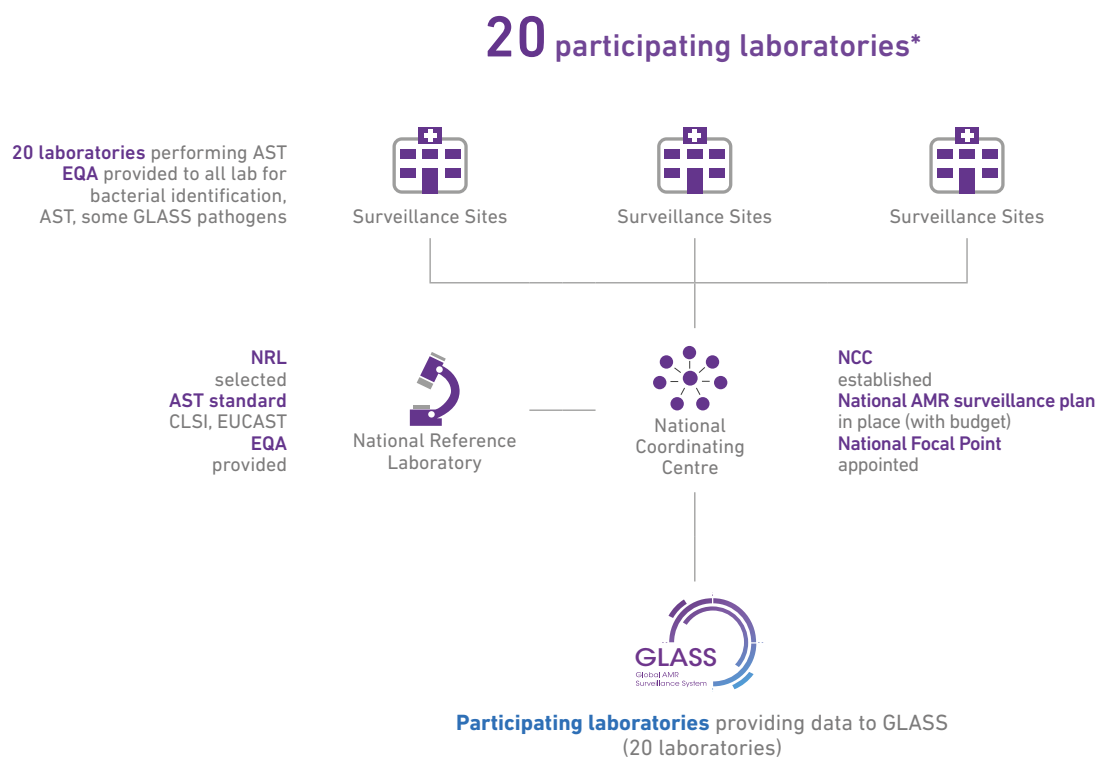


# Switzerland

## Population[1] 8.32 million

Switzerland developed *anresis.ch* which is a national surveillance system for antibiotic resistance and consumption. It collects and analyses antibiotic resistance data provided by a selection of Swiss clinical microbiology laboratories. The collected data represent at least 60% of annual hospitalisation days and at least 30% of Swiss practitioners. The Swiss Antibiotic Resistance Strategy (StAR) was adopted in 2015. The country participates in CAESAR and has been enrolled in GLASS since April 2017.

## Current status of the national AMR surveillance system




*The identification of the total number of surveillance sites submitting specimens to participating laboratories was not possible due to the set up of the national surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *E. coli* | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟠 |
| | | *S. aureus* | 🟢 | 🟢 | 🟢 | 🔴 |
| | | *S. pneumoniae* | 🟢 | 🟢 | 🟢 | 🔴 |
| URINE | 🔴 | *E. coli* | 🟢 | 🟢 | 🟢 | 🟠 |
| | | *K. pneumoniae* | 🟢 | 🟢 | 🟢 | 🟠 |
| STOOL | 🔴 | *Salmonella* spp. | 🟢 | 🟢 | 🟢 | 🟠 |
| | | *Shigella* spp. | 🟢 | 🟢 | 🟢 | 🟠 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🟢 | 🟢 | 🟢 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Switzerland

## Population 8.32 million

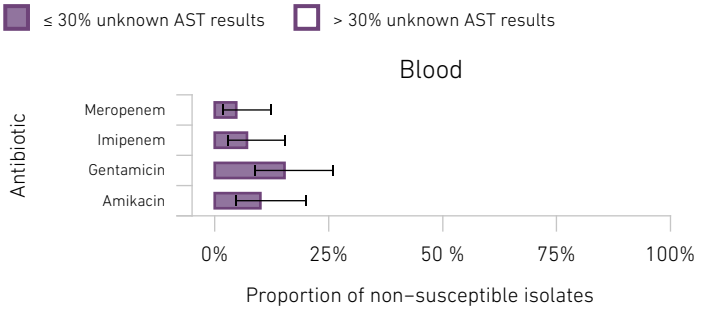
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | - | *Acinetobacter* spp. | 29 | 10 | 34 |
| | | | | *E. coli* | 2 859 | 415 | 1 455 |
| | | | | *K. pneumoniae* | 462 | 139 | 326 |
| | | | | *Salmonella* spp. | 58 | 3 | 18 |
| | | | | *S. aureus* | 836 | 244 | 550 |
| | | | | *S. pneumoniae* | 373 | 17 | 172 |
| **URINE** | - | - | - | *E. coli* | 54 684 | 4 595 | 17 807 |
| | | | | *K. pneumoniae* | 6 614 | 1 032 | 3 192 |
| **STOOL** | - | - | - | *Salmonella* spp. | 302 | 7 | 86 |
| | | | | *Shigella* spp. | 74 | - | 17 |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | 112 | - | - |

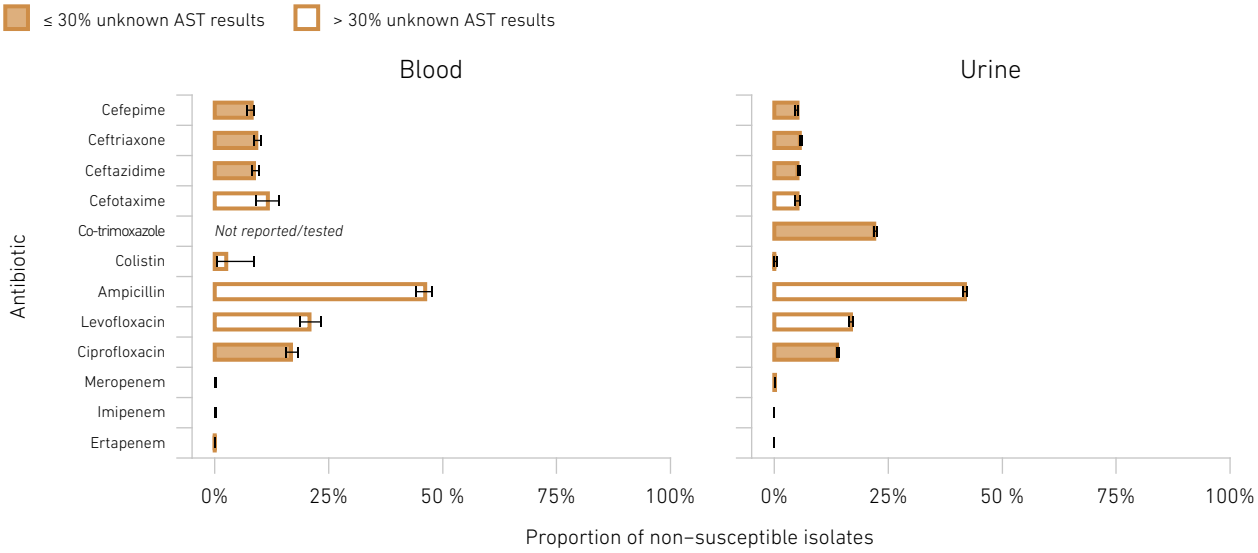
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**




***Escherichia coli***

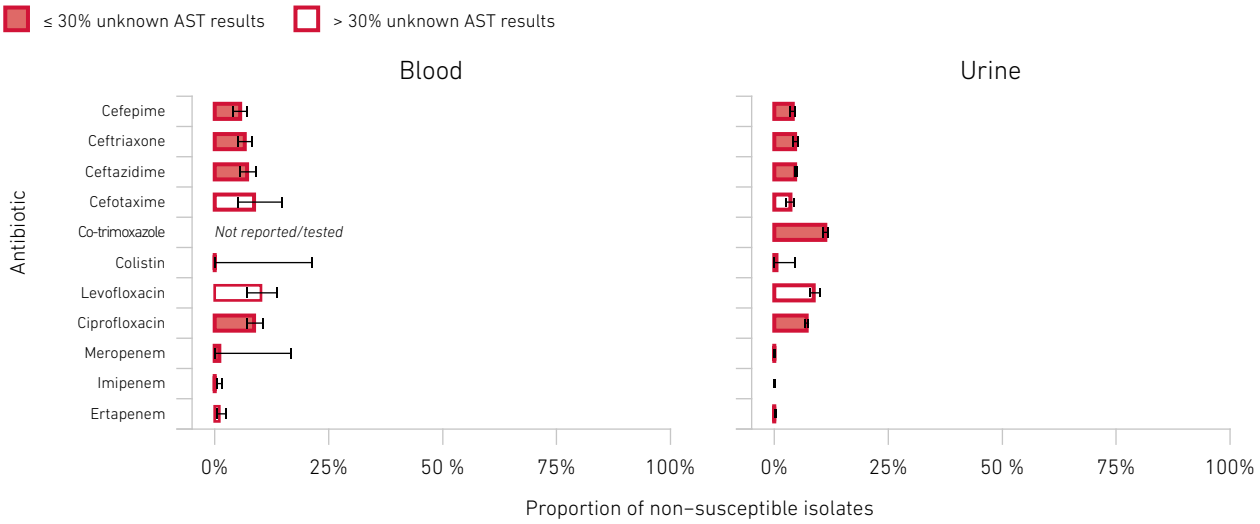



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

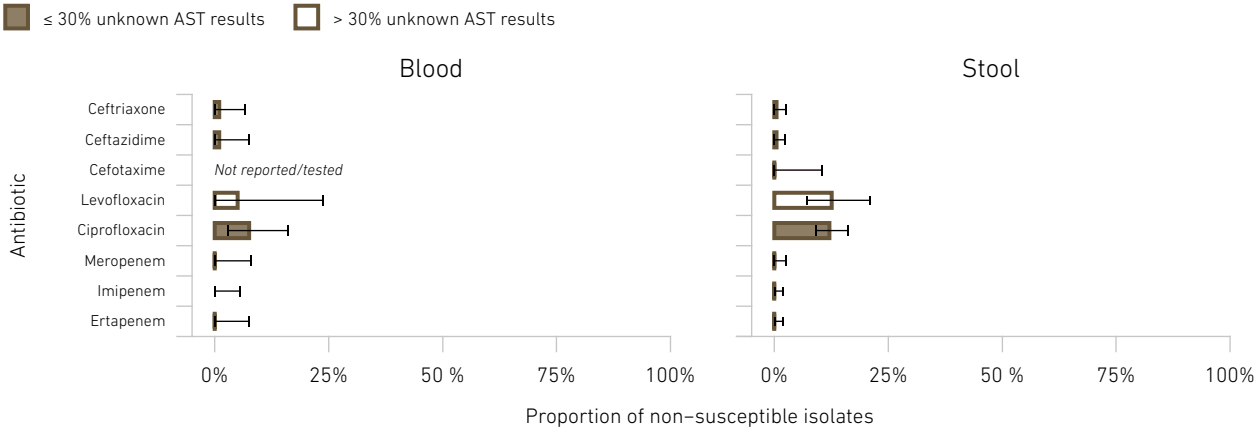
# Switzerland

## Population 8.32 million

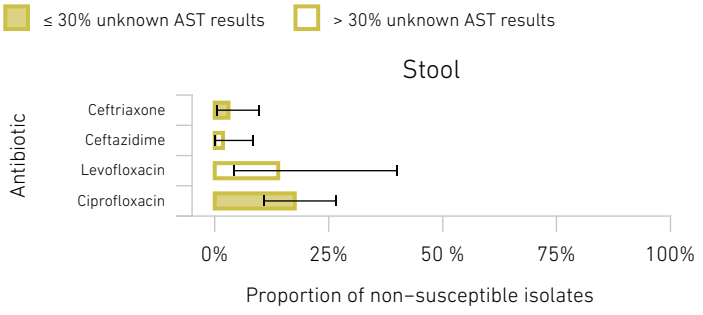
### *Klebsiella pneumoniae*



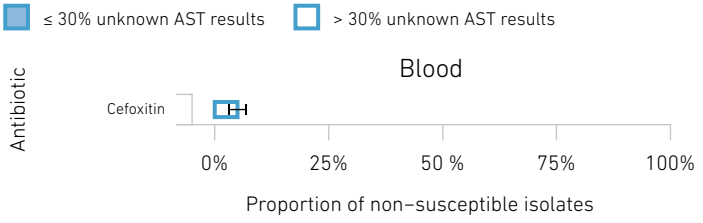

### *Salmonella* spp.




### *Shigella* spp.



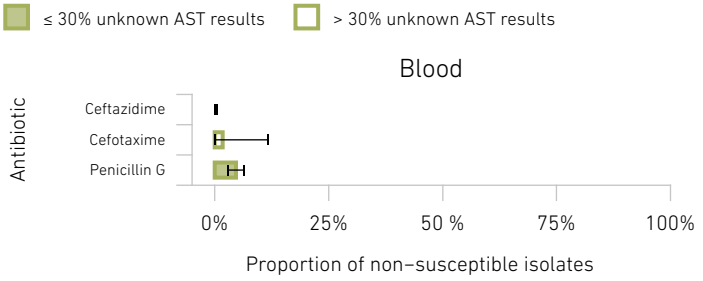

### *Staphylococcus aureus*



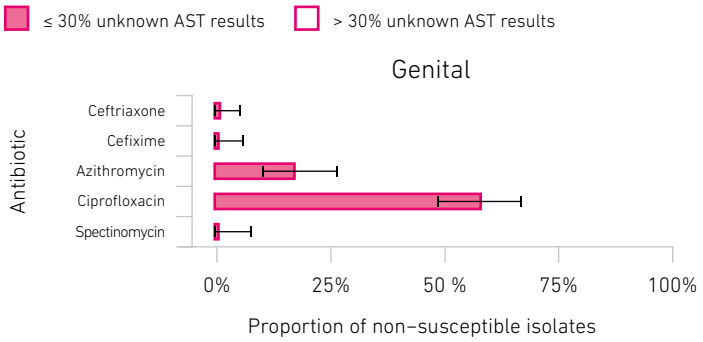
# Switzerland

## Population 8.32 million

***Streptococcus pneumoniae***




***Neisseria gonorrhoeae****




* Due to the frequent use of nuclear acid amplification tests (NAAT) in diagnosis of N. gonorrhoeae infections, resistance data shown in this graph may not be representative for all N. gonorrhoeae isolates in Switzerland

# Thailand

## Population[1] 68.65 million

In August 2016, the Thai government endorsed a national strategic plan on antimicrobial resistance 2017- 2021. Thailand has been enrolled in GLASS since February 2017.

## Current status of the national AMR surveillance system

**1285 surveillance sites**
158 hospitals and 1127 outpatient clinics

**20 laboratories** performing AST
**EQA** provided to all labs for bacterial identification, AST, some GLASS pathogens

Surveillance Sites | Surveillance Sites | Surveillance Sites

**NRL**
selected
**AST standard**
CLSI
**EQA**
provided

National Reference Laboratory

National Coordinating Centre

**NCC**
established
**National AMR surveillance plan**
in place (with budget)
**National Focal Point**
appointed

GLASS

**2 surveillance sites** providing data to GLASS
(2 hospitals)

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | ● | *Acinetobacter* spp. | ● | ● | ● | ● |
| | | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| | | *Salmonella* spp. | ● | ● | ● | ● |
| | | *S. aureus* | ● | ● | ● | ● |
| | | *S. pneumoniae* | ● | ● | ● | ● |
| URINE | ● | *E. coli* | ● | ● | ● | ● |
| | | *K. pneumoniae* | ● | ● | ● | ● |
| STOOL | ● | *Salmonella* spp. | ● | ● | ● | ● |
| | | *Shigella* spp. | ● | ● | ● | ● |
| GENITAL | ● | *N. gonorrhoeae* | ● | ● | ● | ● |

● 100% data collected ● 99-70% data collected ● <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Thailand

## Population 68.65 million

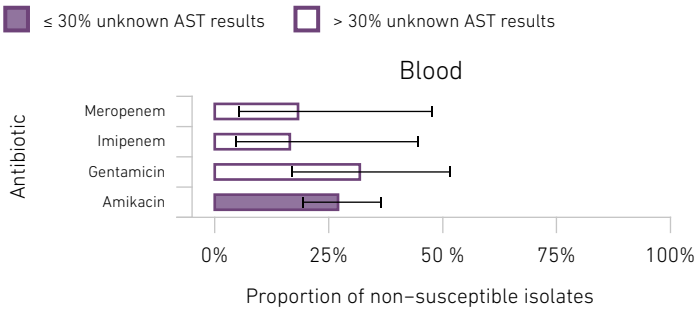
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| **BLOOD** | - | - | 6604 | *Acinetobacter* spp. | - | - | 104 |
| | | | | *E. coli* | - | - | 287 |
| | | | | *K. pneumoniae* | - | - | 162 |
| | | | | *Salmonella* spp. | - | - | 33 |
| | | | | *S. aureus* | - | - | 132 |
| | | | | *S. pneumoniae* | - | - | 22 |
| **URINE** | - | - | 3101 | *E. coli* | - | - | 1 001 |
| | | | | *K. pneumoniae* | - | - | 381 |
| **STOOL** | - | - | 801 | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | 3 |
| **GENITAL** | - | - | - | *N. gonorrhoeae* | - | - | 123 |

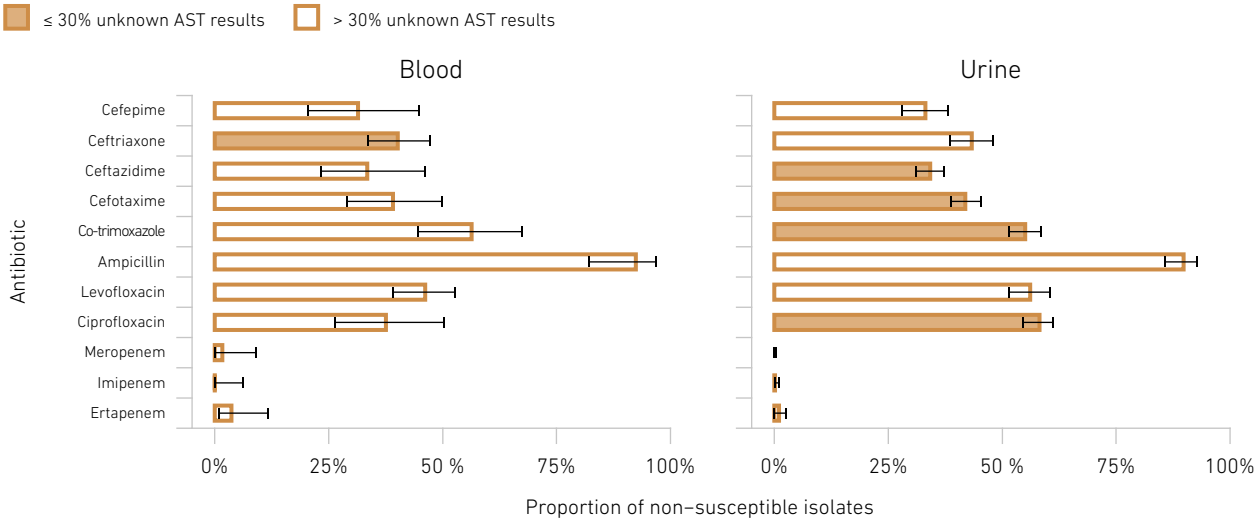
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**




***Escherichia coli***

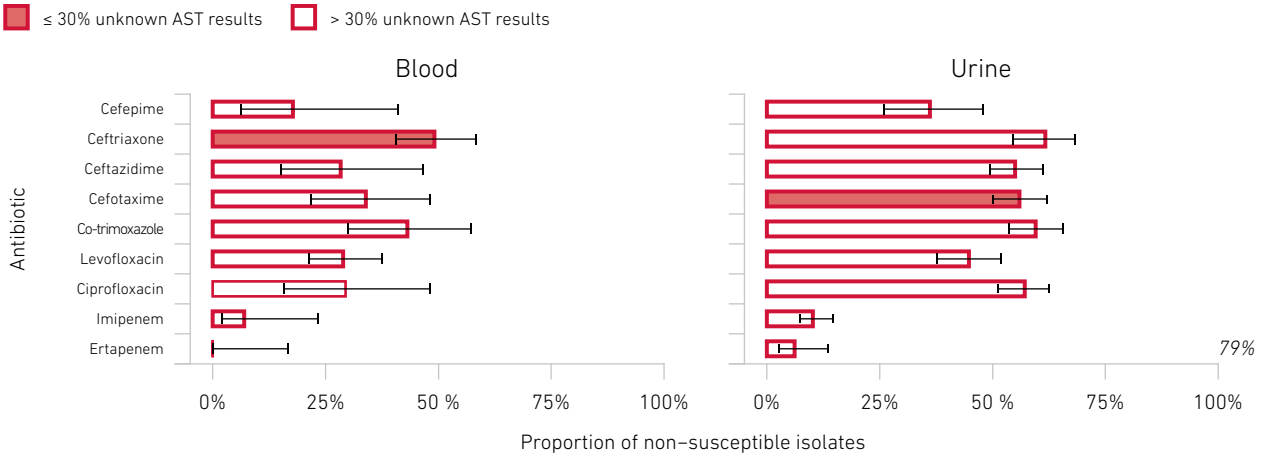



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

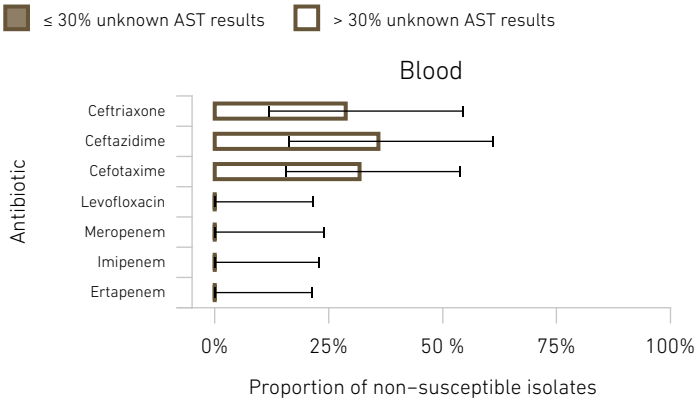
# Thailand

## Population 68.65 million

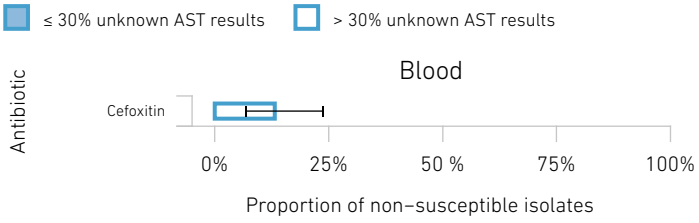
### *Klebsiella pneumonaie*



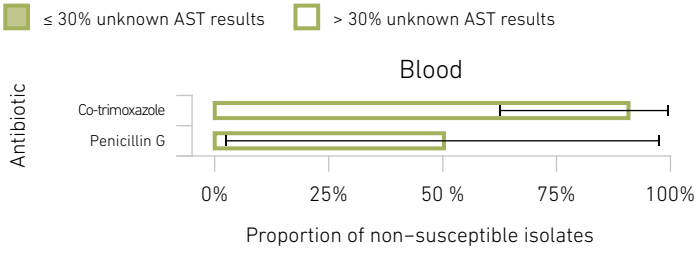

### *Salmonella* spp.



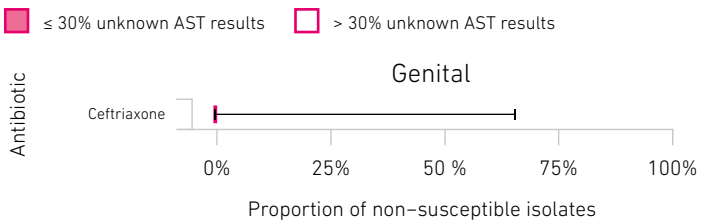

### *Staphylococcus aureus*




### *Streptococcus pneumoniae*




### *Neisseria gonorrhoeae*



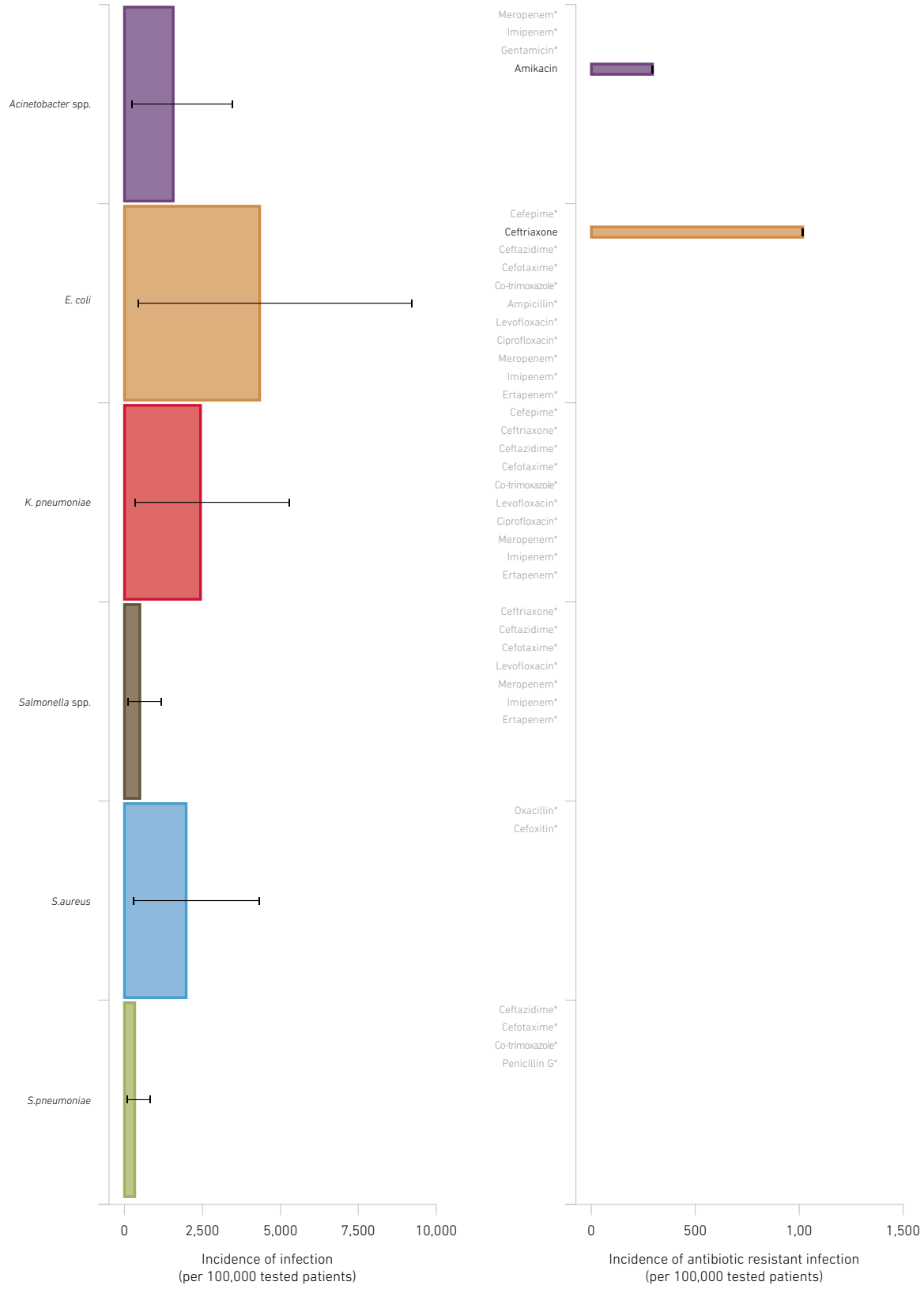
# Thailand

## Population 68.65 million

## Non-susceptible pathogen – antimicrobial combination incidence

Incidence of infection caused by pathogens under surveillance in the tested population per specimen type and infection origin (left). Incidence of AMR under surveillance in the tested population per specimen type and infection origin (right).

**Blood – Unknown infection origin** (n tested = 6604)

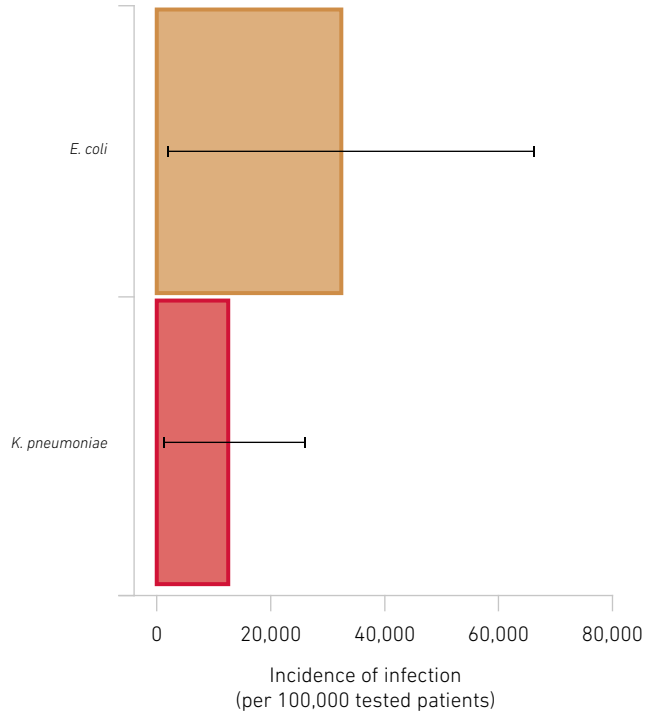


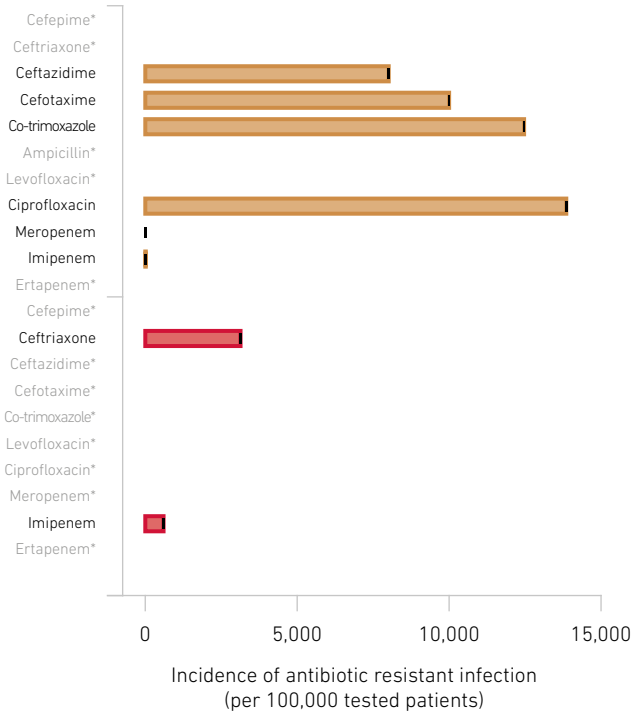

*Antibiotic with >30% unknown AST results

# Thailand

## Population 68.65 million

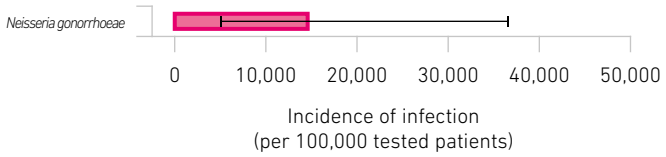
**Urine – infection origin unknown** (n tested = 3101)

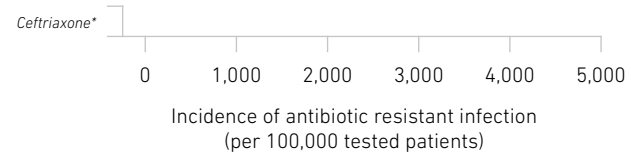



*Antibiotic with >30% unknown AST results

**Genital – infection origin unknown** (n tested = 123)

# Thailand

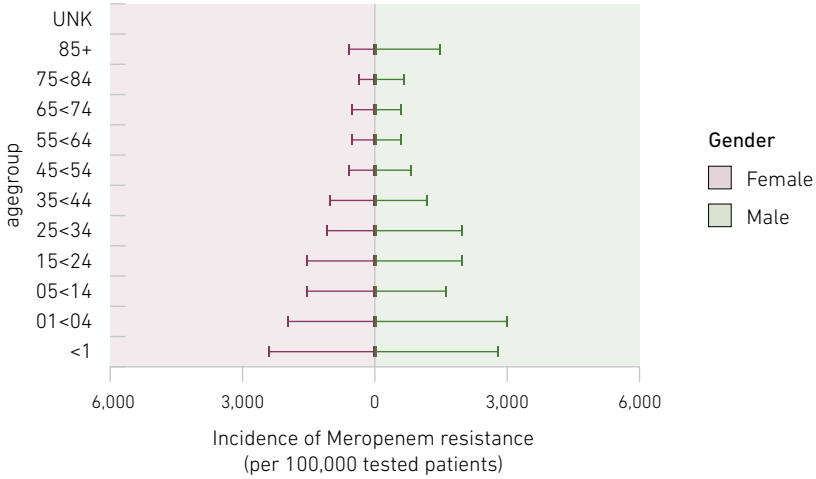
## Population 68.65 million

## Non-susceptible pathogen-meropenem combination stratified incidence[2]

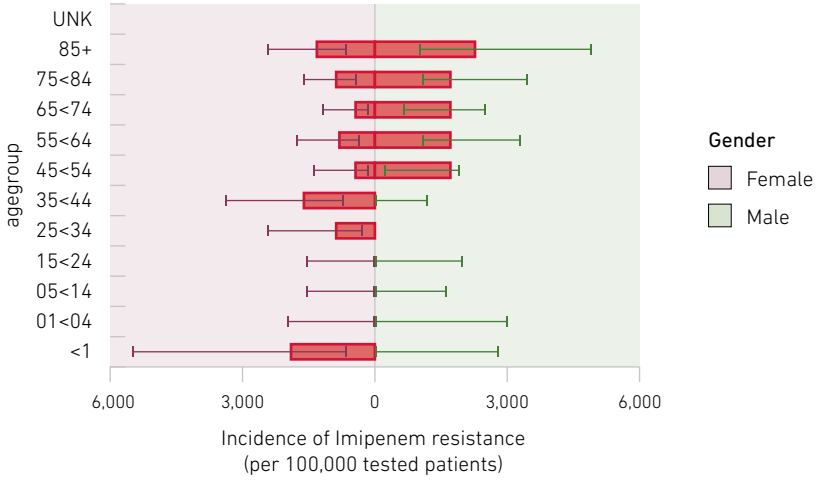
Incidence of infection caused by pathogens non-susceptible to meropenem per specimen and infection origin (right), stratified by age and gender.

**Urine**

***Escherichia coli***




***Klebsiella pneumonaie****




* Data on Imipenem presented because no testing was done for Meropenem

2. Results for isolates with >30% unknown AST results are not shown. Grouping of carbapenem antibiotics was not possible due to results bias generation linked with data aggregation.

# The former Yugoslav Republic of Macedonia

## Population[1] 2.07 million

The former Yugoslav republic of Macedonia is developing its national surveillance system with a network of laboratories covering about 79% of hospitals (2015). The country participates in CAESAR and has been enrolled in GLASS since May 2017.

## Current status of the national AMR surveillance system


*The identification of the number of surveillance sites submitting specimens to the laboratories reporting to GLASS was not possible due to the set up of the National surveillance system

## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🔴 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# The former Yugoslav Republic of Macedonia

## Population 2.07 million

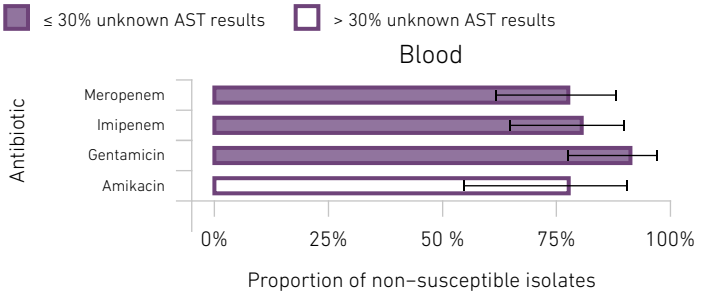
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | 1 | 35 | - |
| | | | | *E. coli* | 1 | 63 | - |
| | | | | *K. pneumoniae* | - | 24 | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | 3 | 66 | - |
| | | | | *S. pneumoniae* | - | 12 | - |
| URINE | - | - | - | *E. coli* | - | - | - |
| | | | | *K. pneumoniae* | - | - | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

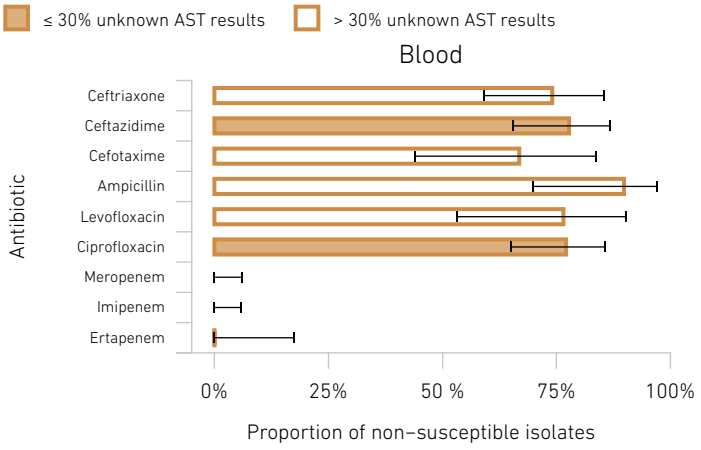
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

***Acinetobacter* spp.**




***Escherichia coli***

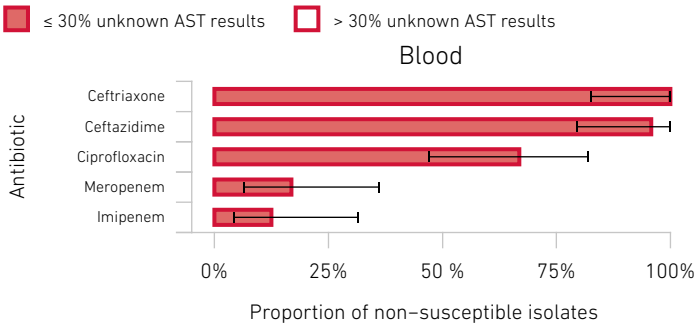



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

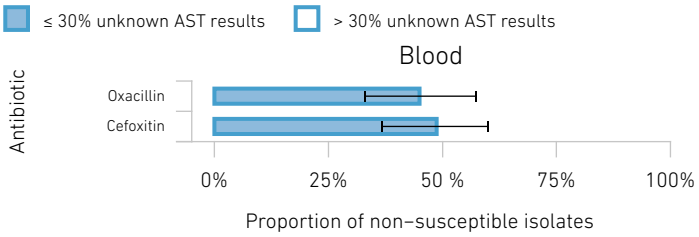
# The former Yugoslav Republic of Macedonia

## Population 2.07 million

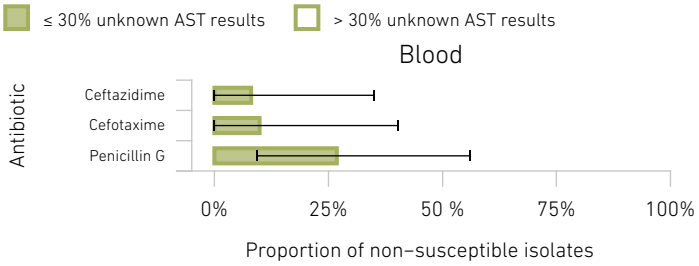
***Klebsiella pneumoniae***




***Staphylococcus aureus***




***Streptococcus pneumoniae***



# Tunisia

## Population[1] 11.27 million

Tunisia is developing its National Action Plan on AMR and is building a national AMR surveillance system. The country has enrolled in GLASS in May 2016.

## Current status of the national AMR surveillance system


## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🟢 | 🔴 | 🔴 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🟠 | 🔴 |
| | | *Salmonella* spp. | 🟢 | 🔴 | 🟠 | 🔴 |
| | | *S. aureus* | 🟢 | 🔴 | 🟠 | 🔴 |
| | | *S. pneumoniae* | 🟢 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🟢 | 🔴 | 🟢 | 🔴 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🟢 | 🔴 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🟢 | 🔴 | 🟠 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🟢 | 🔴 | 🟠 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Tunisia

## Population 11.27 million

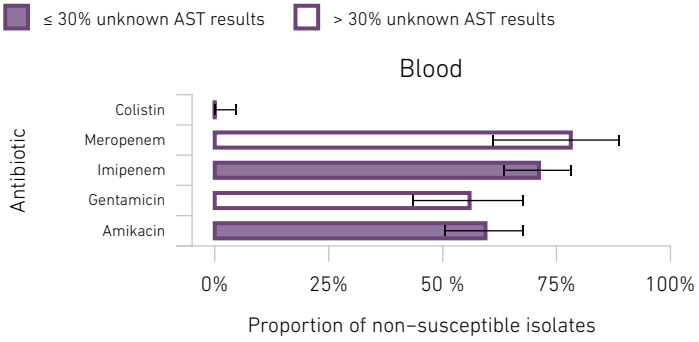
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | 6 | 21 | 114 |
| | | | | *E. coli* | 24 | 28 | 181 |
| | | | | *K. pneumoniae* | 15 | 53 | 261 |
| | | | | *Salmonella* spp. | - | 3 | 18 |
| | | | | *S. aureus* | 36 | 71 | 212 |
| | | | | *S. pneumoniae* | 1 | 1 | 38 |
| URINE | - | - | - | *E. coli* | 1275 | 340 | 5116 |
| | | | | *K. pneumoniae* | 236 | 115 | 1194 |
| STOOL | - | - | - | *Salmonella* spp. | 1 | - | 14 |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | 3 | - | 5 |

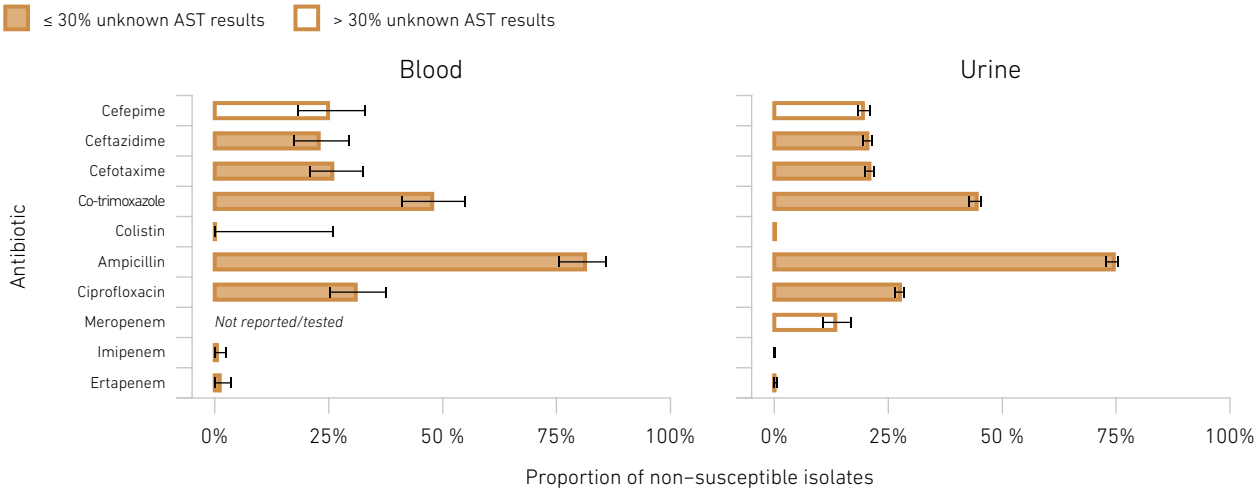
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Acinetobacter* spp.




### *Escherichia coli*

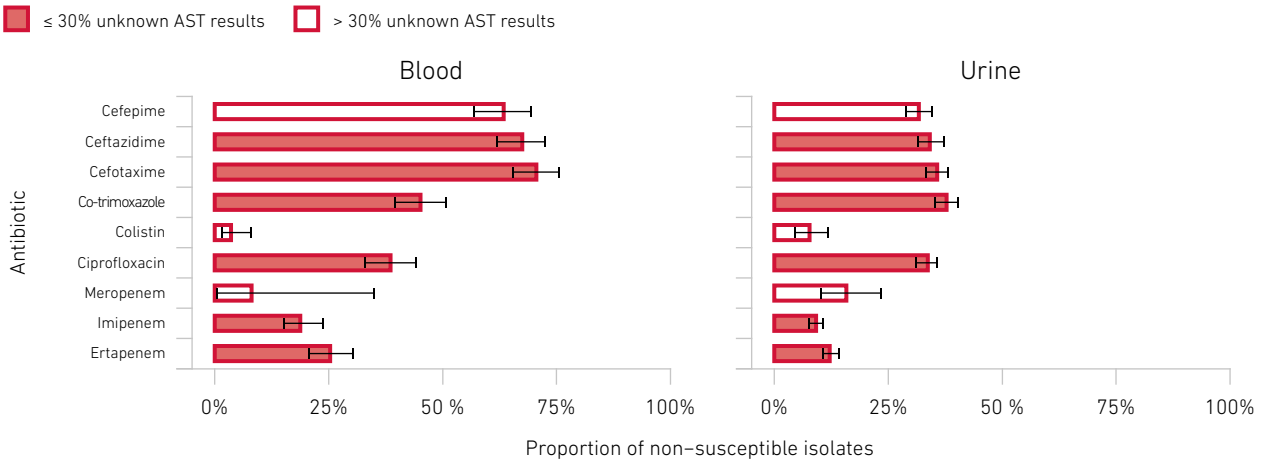



2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

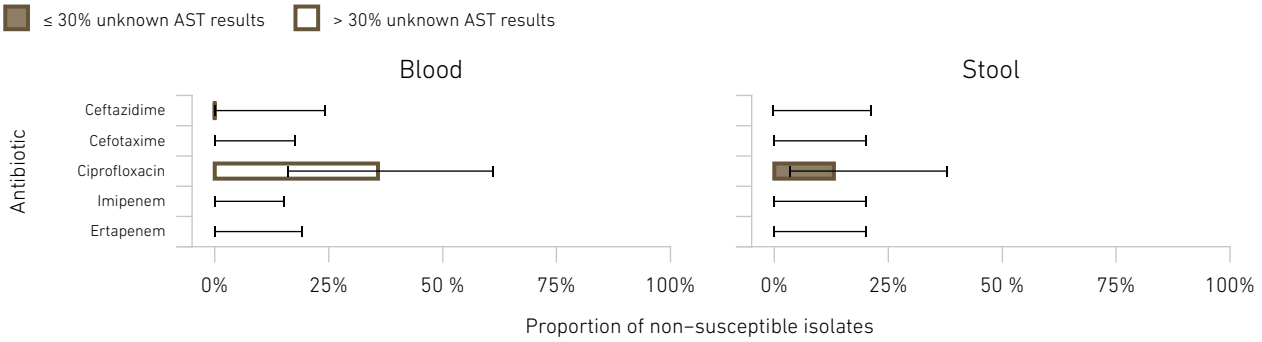
# Tunisia

## Population 11.27 million

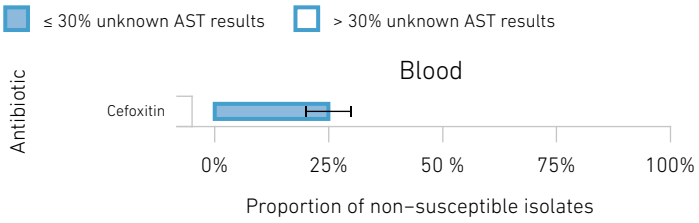
### *Klebsiella pneumoniae*



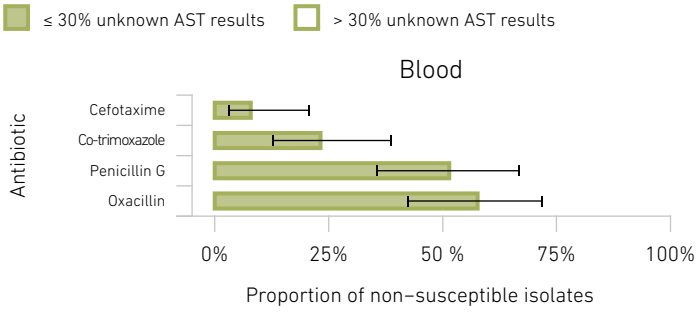

### *Salmonella* spp.




### *Staphylococcus aureus*




### *Streptococcus pneumoniae*

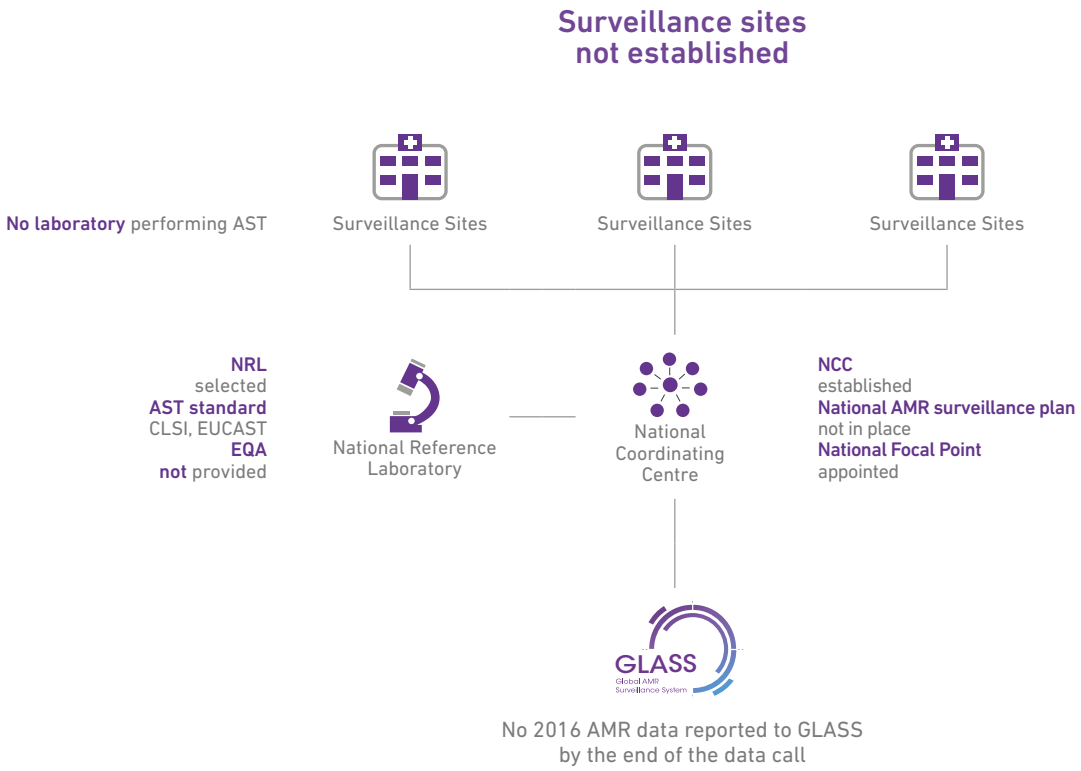


# Uganda

## Population[1] 40.14 million

Uganda is developing its National Action Plan on AMR and is building a national AMR surveillance system. Uganda has been enrolled in GLASS since July 2016.

## Current status of the national AMR surveillance system



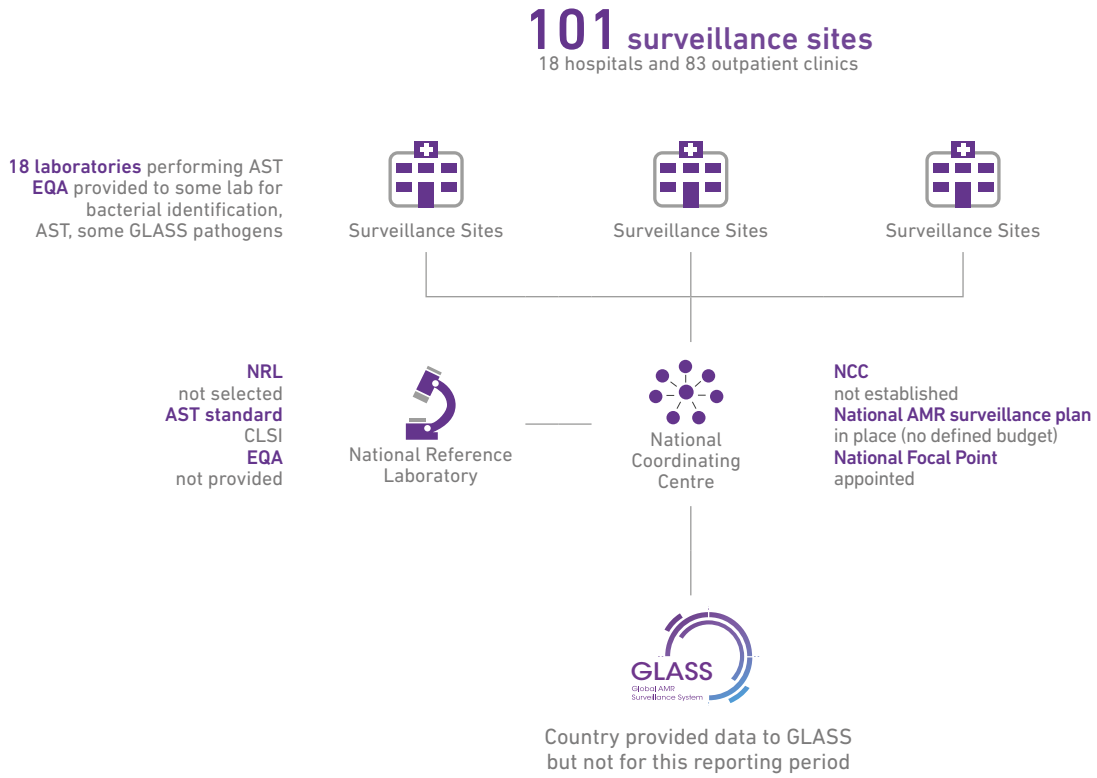

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# United Arab Emirates

## Population[1] 9.15 million

The UAE is conducting surveillance of AMR since 2010 when the Abu Dhabi – Antimicrobial Resistance Surveillance Program (AD ARS) was introduced; in 2015 it was expanded nationwide. The National Action Plan on AMR is under development. UAE has been enrolled in GLASS since April 2017.

## Current status of the national AMR surveillance system



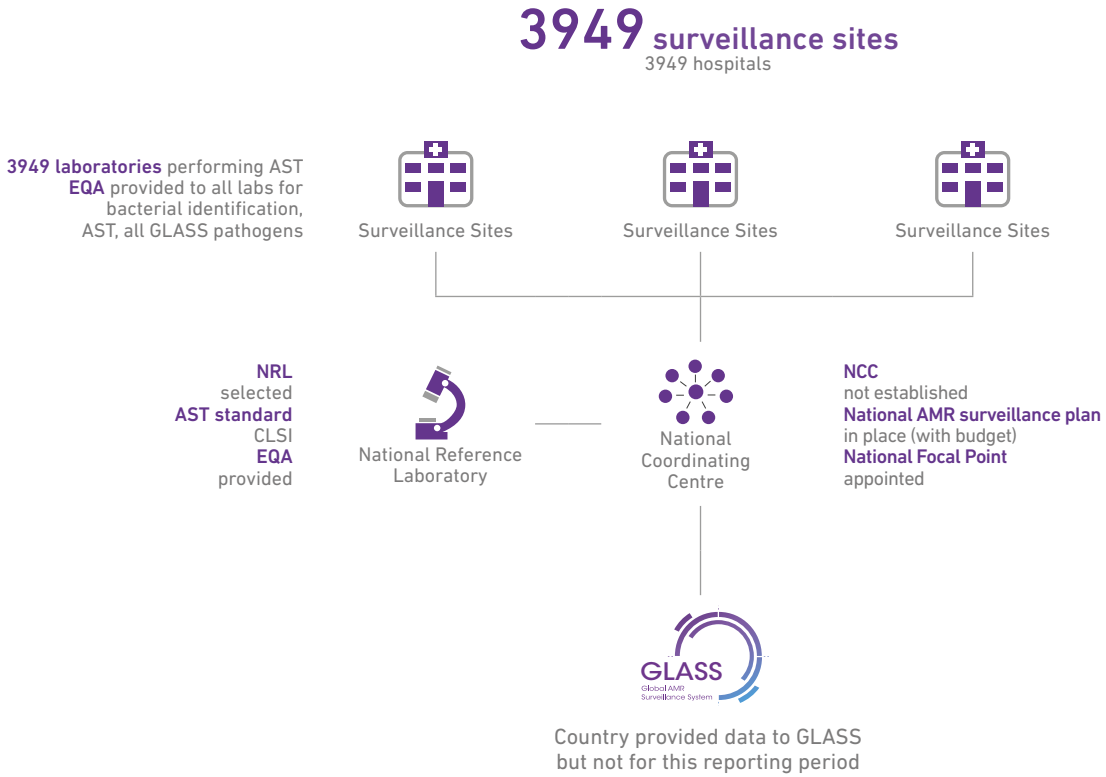

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# United States of America

## Population[1] 319.92 million

Surveillance of AMR in the USA is conducted by several national networks, including the National Healthcare Safety Network (NHSN), the Emerging Infections Program (EIP), the National Antimicrobial Resistance Monitoring System (NARMS), the Gonococcal Isolate Surveillance Project (GISP), and the Antibiotic Resistance Laboratory Network (ARLN). USA is implementing the National Action Plan for Combating Antibiotic-resistant Bacteria published in 2015. The country has enrolled in GLASS in December 2016. Some surveillance data do not conform to GLASS reporting. For example, surveillance for carbapenem-resistant *K. pneumoniae* and *E. coli* is population-based, and therefore measures incidence among residents of a defined geographic area (i.e., counties within a state) rather than percent resistance for isolates or patients tested.

## Current status of the national AMR surveillance system



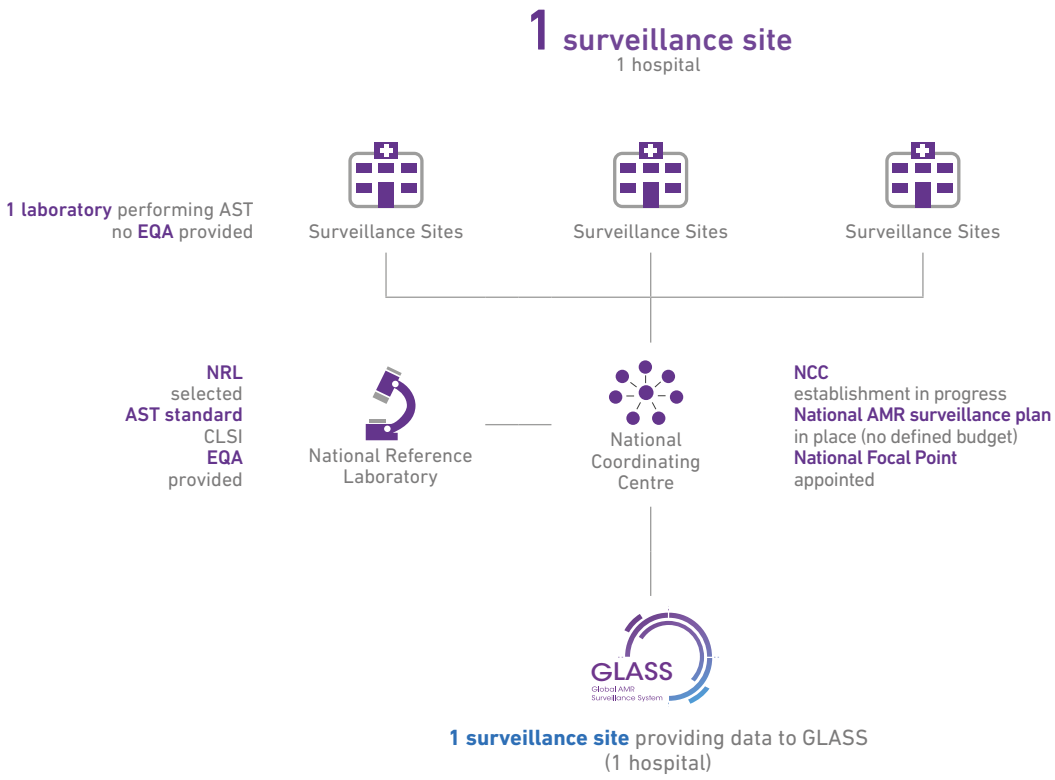

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Zambia

## Population[1] 16.10 million

Zambia has completed development of the National Action Plan on AMR and is building its national AMR surveillance system. Zambia has been enrolled in GLASS since May 2016.

## Current status of the national AMR surveillance system




## Data submission

| Specimen type | Data on number of tested patients | Pathogen | AST results | Age | Gender | Infection origin |
|---|---|---|---|---|---|---|
| BLOOD | 🔴 | *Acinetobacter* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *E. coli* | 🟢 | 🔴 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🟠 | 🟢 | 🟢 |
| | | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. aureus* | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *S. pneumoniae* | 🔴 | 🔴 | 🔴 | 🔴 |
| URINE | 🔴 | *E. coli* | 🟢 | 🔴 | 🟢 | 🟢 |
| | | *K. pneumoniae* | 🟢 | 🔴 | 🟢 | 🟢 |
| STOOL | 🔴 | *Salmonella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| | | *Shigella* spp. | 🔴 | 🔴 | 🔴 | 🔴 |
| GENITAL | 🔴 | *N. gonorrhoeae* | 🔴 | 🔴 | 🔴 | 🔴 |

🟢 100% data collected 🟠 99-70% data collected 🔴 <70% data collected

1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)

# Zambia

## Population 16.10 million

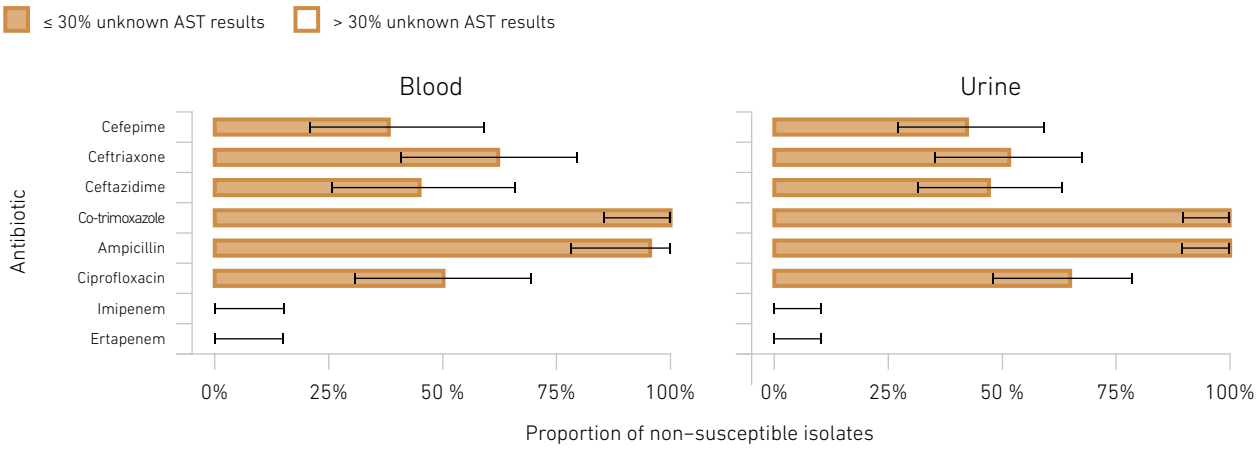
## Data overview - collection between January and December 2016

| Specimen | Number of tested patients | | | Pathogens | Number of patients with positive samples | | |
|---|---|---|---|---|---|---|---|
| | Community origin | Hospital origin | Unknown origin | | Community origin | Hospital origin | Unknown origin |
| BLOOD | - | - | - | *Acinetobacter* spp. | - | - | - |
| | | | | *E. coli* | - | 22 | - |
| | | | | *K. pneumoniae* | - | 99 | - |
| | | | | *Salmonella* spp. | - | - | - |
| | | | | *S. aureus* | - | - | - |
| | | | | *S. pneumoniae* | - | - | - |
| URINE | - | - | - | *E. coli* | - | 34 | - |
| | | | | *K. pneumoniae* | - | 23 | - |
| STOOL | - | - | - | *Salmonella* spp. | - | - | - |
| | | | | *Shigella* spp. | - | - | - |
| GENITAL | - | - | - | *N. gonorrhoeae* | - | - | - |

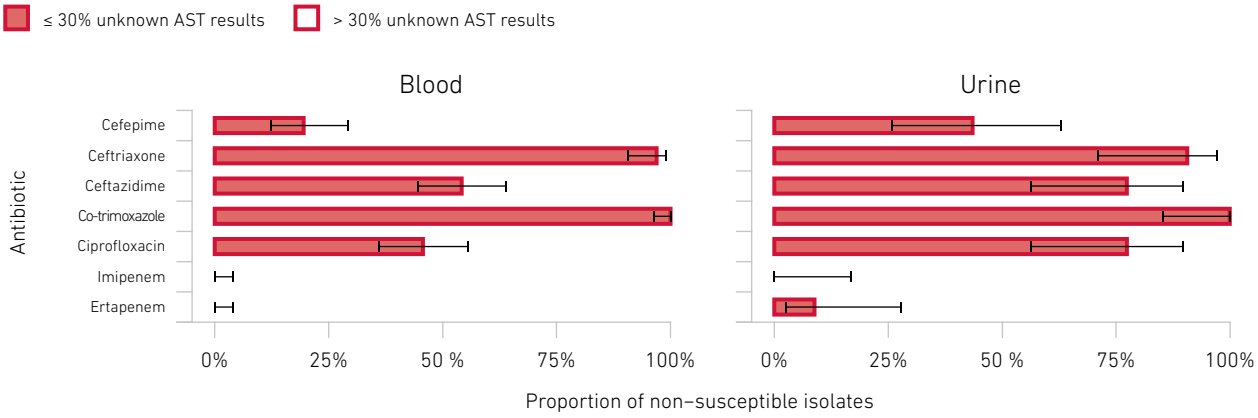
## Pathogens non-susceptibility overview[2]

Proportion of samples with non-suceptibility results for bacteria species and antibiotic under surveillance.

### *Escherichia coli*




### *Klebsiella pneumoniae*



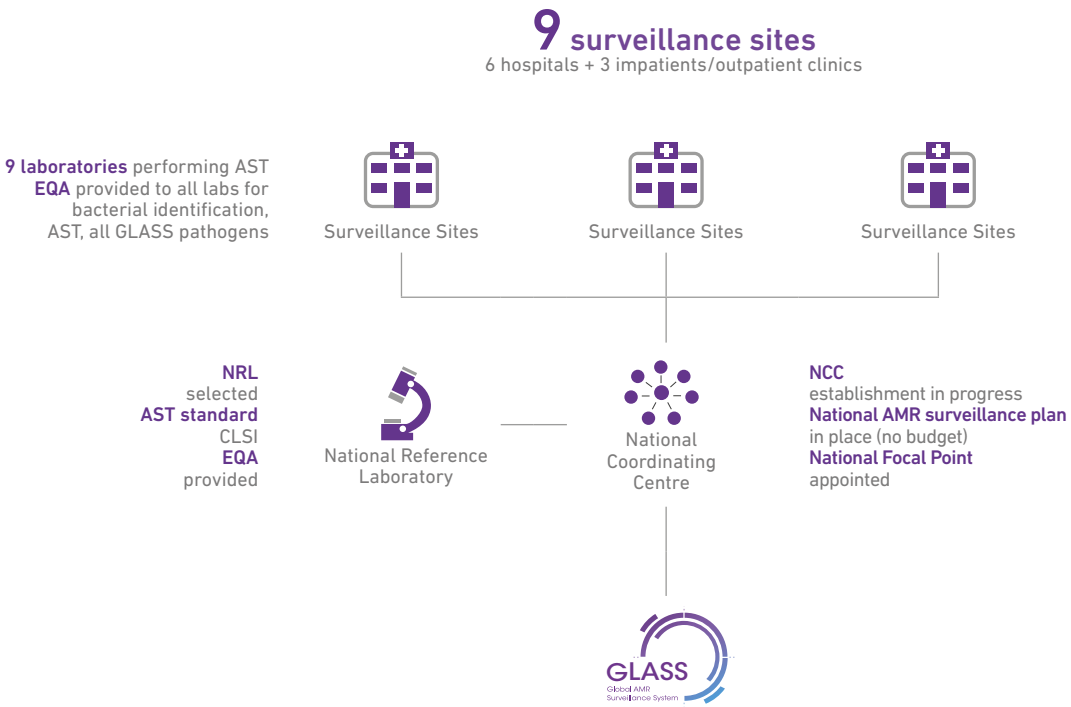

2. AMR rates are not shown for pathogen-antibiotic combination with less than 10 AST result and/or 100% unknown AST results.

# Zimbabwe

## Population[1] 15.77 million

Zimbabwe is developing its National Action Plan on AMR and is building a national AMR surveillance system. Zimbabwe has been enrolled in GLASS since November 2016.

## Current status of the national AMR surveillance system




1. 2015 Population data, United Nations, Department of Economic and Social Affairs, Population Division (2017)


SECTION
04

# GLASS synergies and collaborations

## 4.1 WHO AMR Surveillance and Quality Assessment Collaborating Centres network

At the 68th World Health Assembly (WHA) in 2015, with the same resolution that called for the establishment of GLASS, WHO was entreated to establish a network of WHO Collaborating Centres to support surveillance of AMR and quality assessment in each WHO region [21]. The WHO Collaborative Centres Network was established in December 2016 centres participating in the AMR Surveillance CC Network are required to:

- Cooperate on activities to strengthen countries' capacity for developing and implementing AMR surveillance;
- Support development of tools for AMR surveillance globally, including IT tools;
- Support the establishment of supranational laboratories to provide EQA and reference for testing of unusual patterns of AMR;
- Assist with coordination of epidemiological analysis and development of reports; and
- Contribute to develop special surveillance protocols such as operational research in implementation of surveillance in low- and middle-income settings, protocols to evaluate burden of AMR in humans, and protocols to evaluate the application of molecular tests to AMR surveillance.

On December 2016, the first meeting of the newly established WHO AMR Surveillance CC Network took place in Geneva, Switzerland [43]. During the meeting, a master plan for 2017-2019 GLASS implementation was drafted, and four priority areas of work and target products were defined:

1. Capacity building/ technical support to strengthen microbiology laboratories
2. Capacity building and technical support for the surveillance system
3. GLASS development
4. Increase our understanding of the impact of AMR globally

The work of the WHO AMR Surveillance CC Network has now started, and it is expected to significantly enhance our ability to support particularly-low income countries in their efforts to develop the national surveillance systems. More information on the activities and products developed by the Network can be found on the WHO GLASS website (www.who.int/glass/).

## 4.2 WHO AMR Regional activities

### 4.2.1 African Region (AFR)

#### 4.2.1.1 Regional surveillance initiatives

In the AFR, poor laboratory capacity, infrastructure, and data management hamper effective AMR surveillance [44, 45]. The surveillance structure, and diagnostic and laboratory quality assurance capacities are weak. Country data, when available, are not frequently shared with national bodies. As a result, there is limited information on the impact of antibacterial resistance on humans, animals, and the environment. However, despite the challenges, some activities are implemented or planned.

As of the date of this publication, seven countries (Burkina Faso, Ethiopia, Kenya, Mauritius, Tanzania, South Africa, and Zimbabwe) have had their National Action Plan approved by national authorities, while five (Ghana, Malawi, Nigeria, Uganda, and Zambia) have finalised their National Action Plans and are waiting for approval. The WHO Regional Office for Africa (AFRO) has deployed efforts to improve AMR surveillance and laboratory capacity building. Staff from 13 countries in the Region have been trained in AST and molecular characterisation, thereby increasing the regional capacity for AMR surveillance. 85 laboratories in 45 countries have registered to participate in the WHO/National Institute for Communicable Diseases Microbiology External Quality Assessment Programme, which includes AST for priority bacterial epidemic-prone diseases. This EQA programme is currently being redefined to encompass AMR and antimicrobial

consumption and use, and to reflect the One Health approach. In addition, the WHO Technical Advisory Group on Integrated Surveillance of Antimicrobial Resistance (AGISAR) pilot projects (Section 7.2) in 12 countries aim to strengthen the establishment of integrated surveillance of AMR in the food chain.

#### 4.2.1.2 Link between AFRO activities and GLASS

Since March 2016, AFR embarked in regional trainings of AMR NFPs, including those in charge of surveillance, to foster the development of AMR National Action Plan using the One Health approach and in line with the GAP-AMR strategic objectives. These efforts can also strengthen AMR surveillance in a more coordinated manner and facilitate a possible integration with GLASS.

Ten countries have completed their enrolment in GLASS, while more have already initiated the process. The National Institute for Communicable Diseases in Johannesburg, South Africa has been designated as WHO CC for AMR surveillance and laboratory capacity building and supports the implementation of GLASS in the region.

Finally, Ghana was selected to pilot the WHO Integrated Global Survey on extended-spectrum beta-lactamase (ESBL)-producing *E. coli* using a One Health approach ("The Tricycle Project" (Section 4.4.2.1), which will be run in synergy with GLASS [20] .

### 4.2.2 Region of Americas (AMR/PAHO)

#### 4.2.2.1 Regional surveillance initiatives

In 1996, the WHO Regional Office for the Americas /Panamerican Health Organization (AMRO/PAHO) established the Latin American Network for Antimicrobial Resistance Surveillance (ReLAVRA). The network was created with the goal of improving patient care through informing point-of-care decisions and public health policies. Initially, the network involved eight designated NRLs in eight countries. The surveillance was limited to reporting AMR data for a few targeted foodborne pathogens (*Salmonella* spp., *Shigella* spp., and *Vibrio cholerae*). ReLAVRA was directed towards improving AMR laboratory surveillance in the Americas through the strengthening of laboratory capacity for pathogen identification, and AST. Since then, the AMRO/PAHO has expanded programmes for AMR surveillance, prevention, and control, forging collaborations with different partners and stakeholders.

By 2008, ReLAVRA had included 21 designated NRLs in 18 Latin American countries, and all three countries representing North America, reporting antimicrobial susceptibility data on broad range of pathogens (11 community-acquired pathogens, and 10 nosocomial-acquired pathogens).

In addition to the GLASS pathogens, ReLAVRA covers other *Enterobacteriaceae* (*Enterobacter* spp., *Serratia* spp., *Proteus mirabilis, V. cholerae, Pseudomonas aeruginosa, Enterococcus* spp., *invasive Haemophilus influenzae, Neisseria meningitides*, coagulase-negative *Staphylococci, Campylobacter* spp., and Beta-haemolytic *Streptococci*. The NRLs report on isolates from around 700 sentinel laboratories distributed in the participating countries. By 2015, the laboratories participating in the ReLAVRA network analysed and reported antimicrobial susceptibility information on 3,010,564 isolates [19].

In addition to the broad AMR surveillance approach, the network laboratories alert on isolates with unusual types of AMR (called here "event-driven surveillance"). These analyses are published in epidemiologic alerts, disseminated from the AMRO/PAHO regional office or other Member States, and are determined by incidents of public health importance involving AMR pathogens.

ReLAVRA performance quality is safeguarded through a number of strategies at all levels of surveillance, including internal and external quality control systems. Each of the participating sentinel laboratories has several standard assessment procedures for guaranteeing the quality of test reagents and test performance. Each NRL serves as an external quality control programme that ensures the standard of sentinel laboratories' performance within the national network. NRLs are also responsible for performance evaluations for these laboratories. Two high-quality regional centres, in Argentina and Canada, were designated as regional external quality control programme sites for the network. At the moment, only Argentina is providing the EQA services. These advanced centres are coordinated by the AMRO/PAHO regional office, servings as a technical liaison between all surveillance levels, and provides technical, logistical, and pecuniary support.

In addition, AMRO/PAHO provides needs-focused training aimed at strengthening infection prevention and control, appropriate use of antimicrobials, and the capacities of participating laboratories through access to new tools and introduction of methodologies for AMR detection, including advanced molecular testing, and epidemiological surveillance. AMRO/PAHO also organises bi-annual network meeting to discuss new technologies and tools for surveillance.

To ensure continued communication within the network, bimonthly WebEx meeting with ReLAVRA participants take place, joint by technical experts and partners. These meetings provide an opportunity for the network's participants to discuss topics of interest to the region, and promotes academic and research advancements.

In addition to the ReLAVRA network for the Latin American countries in the region, AMRO/PAHO has launched several schemes aimed at establishing a system for integrated AMR surveillance in the Caribbean countries. These projects are part of a wider blueprint aimed at: 1) building or enhancing antimicrobial surveillance capacities in the Caribbean sub-region through the establishment and implementation of National Action Plans aligned with the objectives of the WHO GAP-AMR [46]; and 2) development of a global network for integrated AMR in the Caribbean sub-region.

#### 4.2.2.2 Link between AMR/PAHO activities and GLASS

All countries are committed to develop their own National Action Plans to address AMR, and AMRO/PAHO is supporting countries to develop their own multi-sectorial approaches that align to the approach of GAP-AMR.

The AMRO/PAHO Office is also working with the countries in the region to foster the participation in GLASS. Brazil, Canada and the United States are already enrolled and have reported data to GLASS. The office is encouraging ReLAVRA participating countries to also enrol in GLASS. The new global AMR surveillance system GLASS creates a unique opportunity to build upon the laboratory assets developed within ReLAVRA and expand the network scope to also include epidemiological data and participate in the global monitoring of AMR.

Moreover, ReLAVRA's approach to AMR surveillance in the region has proven effective in understanding AMR trends, emerging resistance patterns, and setting AMR surveillance standards for diagnosis and treatment, both in the laboratory and at the point of care. This regional experience is informing the development of a global reporting system for new types of AMR. The design of GLASS Emerging Antimicrobial Resistance Reporting will largely benefit in its forming steps from the knowledge and the expertise gained by ReLAVRA.

### 4.2.3 Eastern Mediterranean Region (EMR)

#### 4.2.3.1 Regional surveillance initiatives

The WHO Regional Office for the Eastern Mediterranean (EMRO) conducted capacity review missions and laboratory assessments for implementation of AMR surveillance in a number of countries between November 2015, and July 2017. These missions identified a number of challenges common to all visited countries. Key challenges included: 1) absence of AMR surveillance systems; 2) lack of accuracy and comparability of AMR data and lack of reference strains to set up an internal quality control system; 3) limited availability of AST data due to infrequent request for cultures by clinicians; and 4) limited laboratory capacity to confirm unusual or new resistance patterns.

However, AMR control efforts are now gaining momentum in many countries in the Region, owing to the global commitments and proactive regional advocacy supporting the Member States in advancing their AMR agenda. AMR surveillance networks have also been initiated at the country level, with the aim of extending them to the regional level when countries gain the required capacities for producing quality AMR data.

EMRO has supported development of the National Action Plans on AMR by organising joint consultation workshops with the Ministries of Health and Agriculture as well as One Health partners. So far, nine countries of the region have developed their National Action Plans, in which AMR surveillance and establishing the antibiotic consumption surveillance are among the priorities. Moreover, one of EMRO' s priority outputs is the establishment a Regional Eastern Mediterranean AMR Network based on the regional context to inform policies, strategies and plans.

Two training workshops on WHO methodology for monitoring antimicrobial consumption were also conducted in Pakistan and Sudan in March 2017, with participation of national representatives from Afghanistan, Egypt, Iran, Jordan, Lebanon, Oman, Pakistan, and Sudan. The aim of these workshops was to promote good integration of the surveillance of antimicrobial consumption with other national activities related to antimicrobial use and resistance. To date, sources of data on antimicrobial consumption at the national level have been identified in these countries, and three countries (Iran, Jordan, and Sudan) have provided WHO with data on national consumption of antimicrobials for the years 2014, 2015, and 2016.

#### 4.2.3.2 Link between EMR activities and GLASS

EMRO has provided technical support to the countries of the region for early implementation of GLASS. So far, Afghanistan, Bahrain, Egypt, Iran, Lebanon, Oman, Saudi Arabia, Tunisia, United Arab Emirates, and Pakistan have enrolled in GLASS. Meanwhile in September 2017, EMRO organised two trainings for GLASS NFPs and associated IT professionals around submitting data to GLASS, as well as utilisation of WHONET 2017 for local data analyses and sharing of information [32].

### 4.2.4 European Region (EUR)

#### 4.2.4.1 Regional surveillance initiatives

Currently, most countries in the European Union have well-established national and international

surveillance systems for AMR, whereas countries in other parts of the European Region (EUR) require strengthening or establishment of such systems. The WHO Regional Office for Europe (EURO) and partners have been supporting Member States in this endeavour since 2012 as part of the implementation of the European strategic action plan on antibiotic resistance (2011-2020) endorsed by all 53 Member States of EUR [47].

Currently, two main AMR regional surveillance networks are operating in EUR. EARS-Net is an international surveillance network that includes all 28 European Union countries plus Iceland and Norway. EARS-Net is coordinated by the European Centre for Disease Prevention and Control (ECDC). The network includes surveillance of antibacterial susceptibility for eight indicator pathogens causing bloodstream infections and meningitis; and monitors variations in proportion of AMR among tested isolates over time and place [48]. The complementary network is the WHO Central Asian and Eastern European Surveillance of Antimicrobial Resistance (CAESAR).

### CAESAR

CAESAR is a regional AMR surveillance network, jointly initiated by EURO, the European Society of Clinical Microbiology and Infectious Diseases, and the Dutch National Institute for Public Health and the Environment. CAESAR contributes to the development and population of GLASS and supports all countries in EUR that are not part of EARS-Net to develop national AMR surveillance systems.

Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Montenegro, the Republic of Moldova, the Russian Federation, Serbia, Switzerland, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, Uzbekistan as well as Kosovo (in accordance with United Nations Security Council resolution 1244 [1999] [49]) are actively engaged at various stages of development and participation in CAESAR. So far, nine countries (Belarus, Bosnia and Herzegovina, Georgia, Montenegro, the Russian Federation, Serbia, Switzerland, the former Yugoslav Republic of Macedonia, and Turkey) and Kosovo (in accordance with United Nations Security Council resolution 1244 [1999] [49]) have submitted data to the CAESAR database and their data is included in the CAESAR 2017 annual report [50].

The network enables countries to strengthen AMR epidemiology, as well as laboratory capacity and quality. To facilitate comparison of data throughout EUR, CAESAR aligns with the EARS-Net methodology, in close collaboration with ECDC. Network laboratories are asked to report antimicrobial susceptibility results for the first isolate from blood or cerebrospinal fluid per patient per species per year, including additional isolate and patient information for a pre-specified spectrum of bacterial species and antimicrobial agents. CAESAR collects AST data for nine bacterial pathogens of public health and clinical importance: *E. coli*, *Klebsiella pneumoniae*, *Salmonella* spp., Pseudomonas aeruginosa, *Acinetobacter* spp., *Staphylococcus aureus*, *Streptococcus pneumoniae*, Enterococcus faecalis, and Enterococcus faecium. CAESAR also provides WHONET training to facilitate the transition from paper-based to electronic recording and reporting of AST data. An export function for CAESAR format data has been included in WHONET.

The EQA for EARS-Net is coordinated by United Kingdom NEQAS (https://uknegas.org.uk/), based at Public Health England, London, United Kingdom. In 2013, the EQA was extended to include the countries of the CAESAR network. Each year, an increasing number of CAESAR countries and laboratories participated in the EQA (from 131 laboratories in 8 countries in 2013, to 254 laboratories in 18 countries in 2016) [50].

### Proof-of-Principle pilot projects to initiate AMR surveillance

In addition to the countries and areas currently reporting AMR data to CAESAR, many countries are taking steps and developing the necessary capacity for national AMR surveillance to gain a better insight into the AMR situation in their country, and to participate in CAESAR. However, many countries are facing substantial challenges with the foundation for surveillance activities either being absent, under-utilised or outdated. Facing these challenges requires health system strengthening and strong political support. One of the main challenges is the limited routine antibiotic susceptibility testing due to the underutilisation of microbiological diagnostics in clinical practice. To initiate surveillance in countries where the foundation and structure for surveillance is absent, EURO developed the so-called Proof of Principle pilot projects. The proof of principle AMR surveillance project is designed with the aim of stimulating the taking of blood cultures among people with suspected bloodstream infections to support treatment decisions of clinicians, as well as to start assessing the antibiotic susceptibility of the main pathogens causing community-acquired and hospital-acquired bloodstream infections.

## 4.2.4.2 Link between EUR activities and GLASS

The regional AMR surveillance networks of EURO and ECDC are working closely with the GLASS secretariat to support countries participating in the networks and enrolled in GLASS to avoid additional reporting burden as well as discrepancies in reported national data. EURO has actively fostered the participation of CAESAR countries in GLASS with the aim of all CAESAR countries to contribute to the global system [51].

A special module for CAESAR countries has been created under the GLASS IT platform to account for additional indicators used in CAESAR and to facilitate upload of data relevant to GLASS.

### 4.2.5 South-East Asia Region (SEAR)

#### 4.2.5.1 Regional surveillance initiatives

The recent country profile report on AMR in SEAR published in 2017 provided analysis of the AMR surveillance status of ten countries: Bangladesh, Bhutan, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand, and Timor Leste [52]. Bangladesh, Bhutan, India, Indonesia, Maldives, and Myanmar are at the early stage of surveillance set up, and surveillance guidelines have been developed but not fully implemented. AMR surveillance data exist but are not centralised, with limited analysis and representativeness. Three countries (Nepal, Sri Lanka, and Thailand) possess standardised national AMR surveillance data. However, surveillance development is at an early stage and the scope of antibiotics under surveillance is limited. As a result, data may not be representative at a country level (e.g. limited number of surveillance sites) or of the range of pathogens. Finally, Timor Leste acknowledged that surveillance for AMR is still at the adoption and exploration stage, where surveillance guidelines are yet to be developed.

Experts at a WHO Regional Office for South-East Asia (SEARO) consultation in September 2016 underscored the benefits and needs of IT systems to collect, process, and analyse data at a national centre as one of the priorities for national surveillance data quality improvement [53]. Despite the unprecedented expansion of the internet and IT across Asia, the use of IT-supported surveillance of AMR in the region is limited. SEARO's roadmap proposes directions for countries in the region regarding how AMR surveillance systems could be constructed, acknowledging that IT systems need not come in a "one size fits all" approach [53].

Moreover, SEARO is working to propose a two-tier strategy, which aims to generate deliverables at the country level. The strategy includes strengthening a regional tripartite partnership with the FAO and OIE, and expanding the WHO Integrated Global Survey on ESBL-producing *E. coli* using a One Health approach (Section 4.4.2.1) in SEAR to two additional countries including Indonesia and Sri Lanka. A permanent communication and coordination mechanism in the form of a Tripartite Secretariat has now been established in FAO Bangkok and is facilitated by the secondment of a WHO SEARO liaison officer at FAO/OIE offices in Bangkok.

#### 4.2.5.2 Link between SEAR activities and GLASS

While SEARO is proposing strategic directions and practical solutions for IT to improve the AMR surveillance network at the country level in the SEAR context, it also fosters countries' full participation in GLASS. WHO, when supported by Member States, will advocate to the international partners to mobilise resources and leverage partnerships for technical support. WHO will subsequently work with each country to design a context-based IT system tailored to the existing capacities. The implementation plan will account for training and strengthening human resources to manage the systems. Some system integration could be envisaged, particularly to support countries' participation in GLASS.

### 4.2.6 Western Pacific Region (WPR)

#### 4.2.6.1 Regional surveillance initiatives

Consistent with the objectives of GAP-AMR, the WHO Regional Office for the Western Pacific (WPRO) is implementing the Action Agenda on Antimicrobial Resistance in the Western Pacific, through a three-pronged approach that includes: a) multi-sectoral coordination; b) strengthening country systems to combat AMR; and c) improving awareness, advocacy, and behavioural change to combat AMR [54].

In order to support countries to implement AMR National Action Plans and support regional and country surveillance systems, the Technical Working Group for AMR (TWG-AMR) was established in WPRO, led by the Division of Health Systems but with representation across different divisions and disease programmes. The TWG-AMR has identified the priorities for AMR surveillance development as: enhancing core laboratory capacities at local and national levels; strengthening subnational and national AMR surveillance networks; promoting and supporting the use of standards and methods for collection of epidemiological and AST data and data sharing; encourage development of national data systems; and coordinate a regional AMR surveillance initiative which is proposed to be known as the Western Pacific Regional Antimicrobial Resistance Surveillance (WePARS).

Almost all countries in the Region have developed or are in the process of developing their National Action Plans for AMR. 11 countries, including Australia, Cambodia, China, Fiji, Japan, Malaysia, Mongolia, New Zealand, Philippines, Republic of Korea and Viet Nam have already developed their National Action Plans, with Viet Nam currently undertaking its first review of its plan. Lao PDR, Papua New Guinea, and some Pacific Island Countries are in the process of developing their National Action Plans. All the

National Action Plans include surveillance for AMR and antimicrobial use, and antimicrobial stewardship, as key components. These surveillance systems are nested under the multi-sectoral framework and the One Health Approach. WPRO has been providing support to several countries such as Brunei, Cambodia, Mongolia, Philippines and Viet Nam to build capacity and establish surveillance systems for antimicrobial use as well as antimicrobial stewardship programmes. In Viet Nam, National Action Plan for AMR in the agriculture and animal sector has been developed as well as regulations of antibiotic use in the animal sector.

WPRO is coordinating with FAO and OIE as well as development partners at the regional and national level to ensure a multi-sectoral support and action. Several countries in the region, including Viet Nam and the Philippines, have issued high-level declarations for multi-sectoral action for AMR. The system strengthening, however, is focused on supporting countries to set-up and run their AMR surveillance, antimicrobial use monitoring, and institutionalising antibiotic stewardship programmes in both the health and animal sector.

WPRO has also proposed the development of a Regional Surveillance Network with the aims of strengthening national network and establishing a regional AMR surveillance data-sharing system to provide information for combating AMR in the Region. The focus of this surveillance network is the surveillance of AMR in common bacteria in human health that are not covered by existing pathogen- and disease-specific programmes [55]. Progressively AMR surveillance in the food and animal husbandry sector will also be progressively included. WPRO is working with FAO and OIE to support countries in this area. While the development of a WHO regional surveillance network is ongoing, surveillance of AMR has been a long standing work in many countries in the region.

#### 4.2.6.2 Link between WPR activities and GLASS

Four countries in the Region, namely, Cambodia, Japan, Republic of Korea, and Philippines have been enrolled in GLASS. Japan, Republic of Korea, and Philippines have started submitting data covering key pathogens such as *Acinetobacter* species; *E. coli*; *K. pneumoniae*; *Salmonella* species; *S. aureus*; *S. pneumoniae* and *N. gonorrhoeae*.

## 4.3 Gonorrhoea antimicrobial surveillance

### 4.3.1 Global Public Health Implication

Gonorrhoea is a sexually transmitted infection caused by *Neisseria gonorrhoeae* (gonococcus). This disease is a major public health priority globally: in 2012, WHO estimated that there were 78 million new cases among adults worldwide with a global incidence rate of 19 per 1,000 females and 24 per 1,000 males. The greatest burden is in Asia and Africa [56]. The direct and indirect costs are very high for individuals as well as governments. Furthermore, the emergence of different resistance strains of *N. gonorrhoea* is often followed by a rapid spread of the disease.

Currently, in most countries, the injectable extended-spectrum cephalosporins are the only remaining empiric treatment of gonorrhoea. To make a sustained difference in the continuing problem of multidrug-resistant *N. gonorrhoeae* infection, two overlapping goals must be met: broad-based control of drug resistance and control of gonorrhoea. Both should be approached in the wider context of global control of AMR.

### 4.3.2 WHO Gonorrhoea Antimicrobial Surveillance Programme (GASP)

WHO GASP was initiated in 1990 as a collaborative surveillance programme initiative with the aim of monitoring AMR in *N. gonorrhoeae* worldwide [57]. GASP data have since then informed revisions of global, regional, and national gonorrhoea treatment guidelines developed by WHO and other public health organisations. WHO advises for treatment recommendations to be refined using quality-assured data from recent *N. gonorrhoeae* AMR surveillance, and that the use of an antimicrobial in empirical treatment is discontinued when the rates of therapeutic failure reaches a level of 5% [58]. Thus, it is critical to monitor AMR globally to inform management guidelines as well as public health strategies and policy.

Since 2009, WHO has substantially strengthened the GASP programme. GASP is coordinated by regional coordinating centre/focal points, which collate regional data on antimicrobial susceptibility patterns in *N. gonorrhoeae*. The regional focal points also provide technical support and training to countries to strengthen laboratory capacities, conduct a GASP EQA programme, and curate, maintain and distribute the WHO *N. gonorrhoeae* reference panel strains for EQA and internal quality control [59]. These WHO *N. gonorrhoeae* reference strains should ensure that the gonococcal AMR data from different countries are quality assured, valid, and comparable between countries.

There are significant variations between the WHO regions with regard to the proportion of countries participating in GASP, which antimicrobials are surveyed, the AMR testing methods used, and approach to QA. The number of countries continuously or partially participating in GASP reflects the changing laboratory capacity and availability of financial and technical support to conduct AMR testing and continuous surveillance or surveys. In GASP, the cumulative number of countries reporting AMR data for any antimicrobial increased from 56 in 2009 to 77 in 2014 [58]. However, the number of countries continuously reporting antimicrobial susceptibility data for at least one antimicrobial each year showed a declining trend, from 56 countries in 2009 to 52 countries in 2014 [58]. The WHO GASP data from 2009 to 2014 showed continued widespread gonococcal resistance to penicillin, tetracycline, and ciprofloxacin, increasing resistance to azithromycin and emergence of decreased susceptibility and resistance to extended-spectrum cephalosporins. Over the period 2009-2014, isolates with resistance (azithromycin and ciprofloxacin) or decreased susceptibility or resistance were reported by 66% (51 of 77) of countries monitoring susceptibility to extended-spectrum cephalosporins, 81% (47 of 58) monitoring susceptibility to azithromycin, and 97% (70 of 72) monitoring susceptibility to ciprofloxacin [58]. Thus, there is a need to ensure that AMR data on *N. gonorrhoeae* are collected in a standardised and coordinated way and made available both to inform national AMR programmes and to provide global estimates.

### 4.3.3 Enhanced GASP

Enhanced GASP was set up in 2015 with the aim of monitoring trends in antimicrobial susceptibilities in *N. gonorrhoeae* using standardised sampling and laboratory protocols at selected sentinel sites and reference laboratories. In addition, enhanced GASP supports the characterisation of male patients with gonorrhoea at selected sentinel sites, particularly those infected with *N. gonorrhoeae* strains that are not susceptible to recommended antimicrobials.

Specimens from patients presenting at selected clinics with symptoms suggestive of gonorrhoea are collected and bacterial identification is performed on any culture isolates and those confirmed to be *N. gonorrhoeae* are tested for susceptibility to specific antimicrobials currently recommended to treat gonorrhoea by gradient strips (Etest). Sampling is systematic, epidemiologic data is linked to laboratory results. In addition, the capacity of the identified laboratories to perform gonorrhoea culture and AST is being strengthened through training and the implementation of adequate internal and external laboratory quality assurance systems.

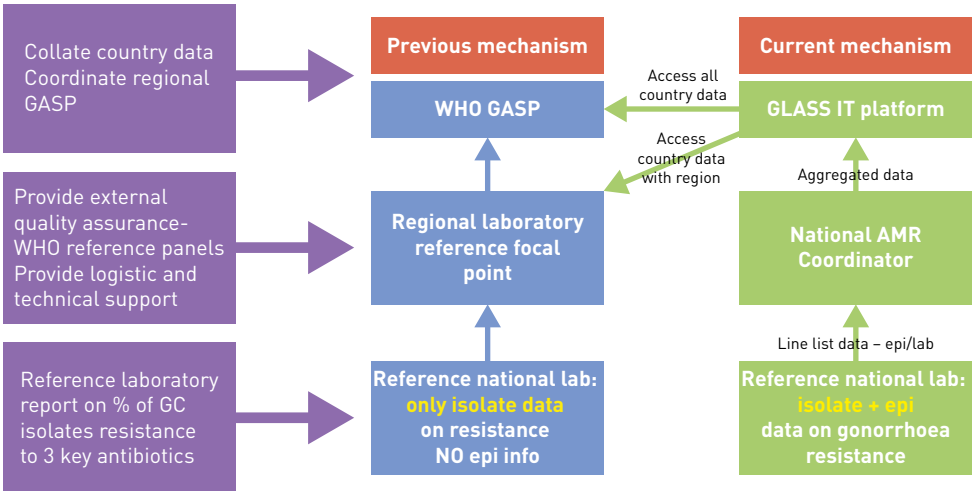
Behavioural and clinical data, such as demographics, prior antibiotic use, sexual behaviour history, and treatment are collected on a case abstraction form for each person enrolled into enhanced GASP. Data from the sentinel sites and laboratories are later merged, sent to the Ministry of Public Health, and monthly progress reports are sent to WHO and the United States Centers for Disease Control and Prevention for QA and technical assistance review.

The experience in the initial implementation phase in Bangkok, Thailand, in 2015 will inform the expansion of enhanced GASP to other countries [60].

### 4.3.4 GASP - GLASS interphase

Approaches are also being developed to monitor gonococcal AMR within GLASS. *N. gonorrhoeae* is already among the eight pathogen included in GLASS routine surveillance. In the initial GASP set up, NFLs report isolate data on resistance to the regional reference laboratory focal points and collated data are then submitted to the WHO GASP. Through the GLASS-GASP interphase (Fig. 4.1), isolate data on resistance will be linked with epidemiological data and laboratory and epidemiological data will be reported to the national AMR coordinator. At the national level, linked laboratory and epidemiological data will be aggregate and reported to the GLASS IT Platform. Access to the national laboratory and epidemiology data will be made available at the country level for treatment guidelines and action. This will ensure country ownership of the data. Access to country data will also be available to the regional laboratory reference focal point and the WHO GASP coordinator to inform global treatment guideline revisions and public health strategies.

**Figure 4.1 GASP-GLASS interphase**




In addition to the routine *N. gonorrhoeae* surveillance, a separate enhanced GASP module has been developed and is included in the GLASS IT platform. GLASS is working closely with GASP to improve national coordination, include the data on AMR in gonococci in the GLASS database and further develop the surveillance methodology and tools. During GLASS first data call, ten countries reported AMR data for *N. gonorrhoeae*.

# 4.4 AMR surveillance in the food chain and environment

## 4.4.1 Global AGISAR guidance and initiatives for an integrated One Health Approach to surveillance of AMR

AGISAR is comprised of over 30 international experts from a broad range of disciplines relevant to antibacterial resistance in the food chain. Its advisory role includes advocating for improved control of antimicrobial use in the food chain using a cross-sectoral, multi-disciplinary One Health Approach, promoting and facilitating integrated AMR surveillance through the development of guidance and national capacity-building projects, and regularly updating the WHO List of Critically Important Antimicrobials [61].

The second version of the Guidance on Integrated Surveillance on Antimicrobial Resistance in Foodborne Bacteria was launched in June 2017 [62] . The purpose of the guidance is to assist WHO Member States, and other stakeholders, in the development of programmes of integrated surveillance of AMR in foodborne bacteria (i.e., bacteria commonly transmitted by food). Integrated surveillance of AMR in foodborne bacteria therefore includes data from relevant food chain sectors (animals, food, and humans) and includes data on both AMR and antimicrobial use, expanding on traditional public health surveillance to include multiple elements of the food chain, to better understand the sources of infection and transmission routes.

### 4.4.1.1 Capacity building on Integrated Surveillance on AMR trainings

The AGISAR group joined the initiative of the Global Foodborne Infections Network, which has been an example of multi-sectoral and multi-institution collaboration working within the International Health Regulations framework to build capacity to detect, control and prevent foodborne and other enteric infections from farm to table.

The 2015-2019 AGISAR framework defined the adoption of training courses and research projects as an important component to build capacity in the Member States [63]. Training workshops have been developed at a regional level to provide training to microbiologists and epidemiologists from the clinical, food, and veterinary sectors across Member States on laboratory techniques and methodologies to detect, isolate, and characterise foodborne pathogens and AMR. In laboratory sessions, microbiologist trainees participate in coordinated activities to establish integrated surveillance at a national level with other stakeholders across disciplines. Epidemiologists are trained in data management, integrated surveillance systems, outbreak detection, and attribution of the source. They also gain experience in collaborating with laboratories in the animal, food, and human sectors and other stakeholders to support the integrated surveillance system. The main objective is to promote integrated, laboratory-based surveillance and foster inter-sectoral collaboration among human health,

veterinary, and food-related disciplines through training courses and various activities around the world. The AGISAR training workshop activity will continue supporting Member States from the Global and Regional level, addressing and supporting the implementation of surveillance with a "One Health" approach.

#### 4.4.1.2 AGISAR integrated surveillance research projects

Another AGISAR capacity building activity is the implementation of research projects. In line with WHO priorities to minimise the public health impact of AMR associated with the use of antimicrobial in food for animals, AGISAR has supported pilot projects to enable Member States to implement or improve a national integrated surveillance system.

A biennial call for proposals is advertised for two types of research projects: 1) one-year projects focused at investigating and characterising foodborne pathogens, including AMR, in at least two sectors out of three sectors (human, food, or animal); and 2) two-year country-specific projects focused on establishing, implementing, or improving the national integrated surveillance system on AMR, in at least two sectors. This should include both *Salmonella* spp. and *E. coli*, as well as monitoring of antimicrobial usage in both animals and humans. These projects are reviewed, accepted, and funded by WHO and partners (e.g. countries, other government agencies, and expert institutions), based on a formal proposal system overseen by the WHO AGISAR secretariat. From 2010 to 2014, 26 AGISAR projects have been supported by this initiative in 25 countries from the six WHO Regions.

Countries where AGISAR projects were supported are listed in Table 4.1:

**Table 4.1 Countries selected for AGISAR projects funded between 2010-2014**

| Year | Countries selected |
|---|---|
| 2010 | Burkina Faso, Cambodia, Cameroon, Kenya and Senegal |
| 2012 | Burkina Faso, Cambodia, Cameroon, Kenya and Senegal |
| 2014 | Bangladesh, Ghana, Kenya, Rwanda, Tanzania, Lebanon, Peru, Uganda, Togo, Gambia and Uzbekistan |

Most of the projects (23 in total) covered three main sectors (humans, animals, and food). The last AGISAR project launched in 2014 also included the environment. This was a multi-country project across Tanzania, Kenya, and Rwanda. In terms of human infection, ten projects focused on *Salmonella* spp., five on *Campylobacter* spp., and 11 on *E. coli*. In the area of food, eight projects worked on *Salmonella* spp., six on *Campylobacter* spp., and nine on *E. coli*. Six projects focused on animals in relation to *Salmonella* spp., and one on *E. coli*.

### 4.4.2 WHO Integrated Global Survey on ESBL E.coli, the Tricycle project using a One Health Approach and GLASS

During the 6th AGISAR meeting held in Seoul, Republic of Korea (June 2015), lessons learned from pilot projects were discussed [63]. Key issues raised during the discussions included the importance and need to gather data in all relevant sectors in integrated surveillance programmes. Following the recommendations of the meeting, a group of AGISAR members developed an initiative focused on establishing a simplified system for integrated surveillance, compared to existing systems that monitor different sectors and record many parameters. As a result, they selected one microorganism cross cutting indicator, *E. coli*, and one resistance mechanism indicator, ESBL. *E. coli* ESBL expression is an indicator frequently followed up in the three main sectors, so a relatively simple survey could be implemented in any country with low or minimal resources.

This AGISAR project will include epidemiological and microbiological protocols designed to be followed in an identical manner in all countries, including those with limited resources. The proposed name is "Tricycle project" to demonstrate the idea that it will simultaneously address three aspects of bacterial resistance (human health, the food chain, and the environment) in a simple and elegant manner designed to provide robust, comparable and valid statistical outcomes. Parallel to the isolation of ESBL-producing *E. coli*, data will be gathered on antimicrobial use.

Project development started in 2016, and a first draft of protocol has been defined. The work will be piloted for 1 year in six countries in four WHO Regions, (Africa, Eastern Mediterranean, South-East Asia, and Western Pacific) and then these countries' results will be analysed in order to modify and finalise the protocol by 2019. The protocol will be rolled out globally by partner agencies as part of GLASS. This surveillance approach will be designed so that it can be implemented in all countries, including those with the fewest resources.

The long-term objective is to analyse the differences among countries in ESBL-production and to search for associations with country-specific factors. The comprehensive and combined data thus gathered by each sector will be analysed and data compared between countries to characterise the current patterns and evolution of the ESBL-*E. coli* pandemic, which will serve as a highly representative estimate of the global antimicrobial threat.

# 4.5 Antimicrobial consumption / use monitoring

## 4.5.1 Role of antimicrobial use in developing resistance

Optimising the use of antimicrobials is one of the five key strategies in the GAP-AMR. It has been estimated that as much as half of all antimicrobials used in human health care in countries that are part of the Organisation for Economic Co-operation and Development (OECD) can be considered inappropriate [64]. Consumption of antimicrobials is one of the main drivers of AMR in both humans and animals. Antibiotics kill susceptible bacteria, and allow antibiotic-resistant bacteria to proliferate. Broad-spectrum antibiotics increase the selective pressure of bacteria and stimulate the emergence of multi-drug resistant pathogens [65]. Ecological studies have demonstrated almost linear relationships between antibiotic consumption and the prevalence of AMR. More recently, a joint report by the ECDC, European Food Safety Authority (EFSA), and European Medicines Agency found evidence of similar associations between antimicrobial consumption and AMR in humans and food-producing animals, and between food-producing animals and humans for several antimcrobial agents and pathogens [66]. Selecting the appropriate antibiotic can be challenging; there is a relatively large number of antibacterial substances compared to other antimicrobials, and antibiotics often target a range of pathogens depending on the spectrum of activity of the substance.

## 4.5.2 WHO Global antimicrobial consumption monitoring system

The WHO global antimicrobial consumption monitoring system provides a common methodology for Member States to measure the consumption of antimicrobial agents and acts as common source of information on the consumption of antimicrobials worldwide [67]. The WHO methodology measures *consumption data* (i.e. data derived from aggregated data sources [macro-level data]), as opposed to *antimicrobial use data*, which refers to estimates derived from patient-level data (micro-level data). Consumption data is a proxy estimate of the use of antimicrobials. Antimicrobial consumption data informs on which antimicrobials are used and in which quantity, while antimicrobial use data informs on how antimicrobials are used.

Antimicrobial consumption should be monitored by all Member States, and can provide information on the patterns of use of antimicrobials and identify change in use at the national level if data is collected regularly making it a useful tool for assessing national interventions to improve the use of antimicrobials. Monitoring of antimicrobial consumption can be used to strengthen national pharmaceutical systems and to combat AMR.

The development of the WHO methodology to monitor antimicrobial consumption globally started in 2016. Existing and similar international monitoring systems were used as reference: for example, ESAC-Net, managed by the ECDC, has been in place since 2001. The ESAC-Net database contains data on antimicrobial use since 1997 from up to 30 countries, and was the only project running a monitoring system at the regional level for many years was [68, 69]. Additionally, in 2017 WHO EURO published collated antimicrobial consumption data from non-European Union countries [70].

In principle, the WHO methodology is based on the Anatomical Therapeutic Chemical classification and the Defined Daily Dose (DDD) metrics developed by the WHO CC on drugs statistic methodology in Oslo, Norway [71]. The aim is to collect aggregated data on consumption of antimicrobial medicines available on the market, at a national level on annual basis, including information on the substances, route of administration and content, and the number of packages sold during the period of surveillance.

There are several potential sources for data on antimicrobial consumption that can be grouped into four levels: production and import; public or private wholesales; hospital and retail pharmacies; insurance companies. Countries can either contact the sources directly and request consumption data, or use intermediate agents like research marketing companies that have access to these data sources in some countries.

Following to the development of the methodology, WHO subsequently rolled out the 2016-2017 cycle of data collection that sought consumption data for 2014-2016. For EUR, WHO collects antimicrobial consumption data on a regular basis through its dedicated regional project in Europe, and uses a stepwise approach to enrol countries in the other

regions. As of October 2017, 25 Member States have received support by the WHO in developing national programmes to monitor antimicrobial consumption, and work is ongoing to enroll additional countries from the different regions.

The WHO methodology has been designed to provide estimates of antimicrobial consumption that are comparable to the animal and agriculture sectors. This is important, because AMR has no barrier between humans, animals, and plants, and the use of antimicrobials in any of these sectors will affect resistance in all sectors. In 2015, OIE developed a similar methodology for monitoring antimicrobial consumption in food producing animals and published its first global report on antimicrobial consumption in food producing animals in 2016 [72]. A global report on antimicrobial consumption in the human sector is expected to be published in 2018, and the collaboration between WHO, FAO, and OIE is ongoing.

### 4.5.3 Future of global monitoring of antimicrobial consumption and integration whith GLASS

The 2016-2017 cycle of data collection of antimicrobial consumption can be considered as a pilot phase for WHO and the initial set of enrolled countries. WHO plans to integrate the monitoring of antimicrobial consumption into the GLASS platform as a separate AMC module in 2018. The GLASS platform facilitates the exchange of data between countries and WHO, and includes elements related to data submission, data validation, and data analysis. In the short and medium term, integration is important for the sustainability of AMR activities in general at the country level, throughout the consolidation of the different surveillance activities under one common umbrella. In the medium and long term, having AMR and AMC activities in one common repository facilitates research by allowing analysis between AMC and AMR data at national, regional, and global levels.

Moreover, because antimicrobial consumption monitoring does not provide information on how antimicrobials are used, WHO is working on developing other tools that complement the monitoring of antimicrobial consumption by providing information on the prescription, dispensing, and use of antimicrobials at the patient level. In particular, WHO is developing global protocols for point-prevalence surveys on antimicrobial use in hospitals and community settings (primary care) that will be released during 2017 (hospitals) and 2018 (community). The protocols allow countries to survey individual health facilities. In order to obtain nationally representative estimates of antimicrobial use, a representative sample of facilities and/or communities will have to be sampled for the point-prevalence survey.


SECTION
05

# Conclusion

Following the call for country enrolment in March 2016 and as of 9 December 2017, more than one fourth of WHO Member States were enrolled in GLASS. The rapid increase in country enrolment and active participation in a global system to monitor AMR reflects a collective understanding and engagement to support the global effort to control AMR. This report includes data not only by countries with previously existing and fully operational surveillance systems, but also from brand new systems shaped following GLASS guidelines. The results gathered during this first GLASS data call, both on status of National AMR surveillance systems and on AMR rates, show that more and more countries are working towards achieving a status that will enable them to report data in a more complete and systematic manner.

Frequently, AMR surveillance systems report only on the proportion of resistance among tested isolates, which may not be linked to patient epidemiological information nor inform on rates of occurrence in the population. Countries acknowledge the value of reporting data that combines both microbiological and core epidemiological information and data provided included variables such as gender, age group and infection origin, in addition to microbiological results. GLASS encourages countries also to report on population data. Five countries[1] were able to provide population data allowing for the calculation of AMR incidence rates in the tested population.

The calculation of incidence rates by age groups and infections types is key to inform and direct mitigation strategies and interventions to control AMR in the most affected groups. The AMR surveillance standards established by GLASS proved to be a valuable and feasible methodology and represented a major achievement for both participating countries and GLASS.

## Challenges and future steps

While the achievements of GLASS thus far are clear, it is also important to identify and critically assess the limitations and gaps of the early implementation phase. Detailed technical limitations are summarised in Section 3.1.3.

There is still large variability in terms of data submission, not only with respect to the types of data submitted, but also their completeness. The capabilities of different countries to structure and run surveillance systems vary, and are linked to a large number of factors, including personnel training, availability of funds, and infrastructure. Some countries still face huge challenges in building their national surveillance systems and although not all have provided AMR data, they have shown commitment by sharing information on the status and the development of their surveillance systems with GLASS. Priorities and resources for AMR surveillance will vary between countries, and therefore flexibility has been built into GLASS to allow data collection from countries in different stages of surveillance system development.

GLASS promotes diagnostic stewardship for optimisation of diagnostic tests to ensure quality-assured, standardised identification of bacteria and AST in patient management. A good example of an effort to introduce antimicrobial stewardship in countries is the Proof-of-Principle project (Section 4.2.4.1) implemented in the European Region by the WHO Regional Office. Diagnostic stewardship also supports the responsible use of antimicrobial agents. Moreover, there is a need for harmonised, reliable, affordable, and rapid AMR diagnostic testing for primary and secondary health-care settings, point-of-care and laboratory based testing, and a need to improve laboratory capacity in countries. Together with WHO Regional Offices, Country Offices, and the AMR Surveillance Collaborating Centres Network, GLASS is supporting countries to build national laboratory capacity and providing technical support for microbiology laboratories in countries through a range of activities. Technical assistance is prioritised in low-income countries for the development and operation of NRLs, EQA, and quality management, and to provide training on the performance of AST and on interpretation and reporting of results. In addition, GLASS is in the process of creating a global network of supranational laboratories to support AMR proficiency testing and the development of a laboratory tool to identify AMR laboratory needs and capacities. Technical guidance is also being developed for the detection and reporting of colistin resistance and the use of molecular methods to support AMR surveillance.

1. Latvia, Finland, Republic of Korea, South Africa and Thailand

Other gaps in the early implementation phase of GLASS are acknowledged, including the lack of a sampling strategy to produce AMR data that can be inferred as representative of the population in a given catchment area, as well as a system for early reporting of emerging AMR. In addition, there is currently no global surveillance of AMR in fungal infections. Efforts are being made to address these gaps with the support of the WHO AMR Surveillance and Quality Assessment Collaborative Centers Network and other partners. These include a system for early detection, reporting and mapping spread of emerging AMR mechanisms; a framework for AMR surveillance in invasive fungal disease ; and protocols for assessing AMR burden.

GLASS has combined synergies between WHO surveillance initiatives related to AMR in common bacterial pathogens such as AMR in the food chain, in *N. gonorrhoeae*, and antimicrobial consumption monitoring, and new modules within the GLASS IT platform have been built to facilitate further integration of analysis and reporting. Particularly with respect to antibacterial resistance and foodborne AMR, GLASS recognises and supports the development and implementation of integrated surveillance to identify resistance patterns related to the food chain. Integrated surveillance through coordinated surveillance efforts will allow for the systematic collection of comparable AMR data in the human, animal and environment ecosystems, and they are key to recognizing links within and between these systems to understand potential drivers of resistance. To achieve this, GLASS recommends the WHO Guidelines on Integrated Surveillance of AMR in Foodborne Bacteria [73] as the framework to help countries outline their strategies to promote and implement integrated surveillance.

In this beginning of the first 5 year cycle (2015-2019) GLASS has already proven to be a valuable and feasible global system for AMR monitoring. Towards the end of this first cycle, the system will be revised to include new developments, incorporate lessons learned and consider expansion of scope to include other pathogens and specimens according to country needs.

Advocacy and communication to engage and support countries on this journey are paramount, as is collaboration with other partners that work on implementation of AMR surveillance and capacity building. GLASS has benefitted from the expertise of the GLASS AMR Collaborative Platform, which comprises WHO Collaborating Centres and partner technical institutions. These groups will continue to work together to further develop the AMR surveillance system. GLASS will also continue to collaborate closely with international and regional AMR surveillance networks [74].

Despite the limitations of the current phase, GLASS is working towards the broader collection of an unprecedented set of information related to AMR at global level. Most importantly, together with countries and partners, WHO is leading the way towards the further development and consolidation of a functional and comprehensive global surveillance system, which will be able to operate in diverse economic and socio-political contexts, and still provide timely, reliable, and actionable data. Communication, harmonisation, and coordination between international, regional, and national organisations are key priorities for the success of the system.

# ANNEXES

# ANNEX I: Pathogens under GLASS surveillance

## *Acinetobacter* spp.

The *Acinetobacter* genus comprises many species that can be divided between the *Acinetobacter* baumannii group (consisting of the species A. baumannii, A. pittii and A. nosocomialis) and the non-baumannii group consisting of many environmental species with low pathogenicity. Species belonging to the A. baumannii group have been identified as pathogens in nosocomial pneumonia (particularly ventilator-associated pneumonia), central line-associated bloodstream infections, urinary tract infections, surgical site infections, and other types of wound infection [51].

*Acinetobacter* spp., especially those belonging in the A. baumannii group, are intrinsically resistant to many antimicrobial agents due to their selective ability to exclude various molecules from penetrating their outer membrane. The risks for acquiring a multidrug-resistant strain include prolonged mechanical ventilation, prolonged intensive care unit or hospital stay, exposure to infected or colonised patients, increased frequency of interventions, increased disease severity and receiving broad-spectrum antimicrobial agents, especially third-generation cephalosporins, fluoroquinolones, and carbapenems [75].

In settings with high carbapenem resistance rates among *Acinetobacter* spp., colistin is usually the only effective antibiotic left. With an increase in colistin use, colistin resistance is emerging, mostly among carbapenem-resistant A. baumannii strains, with the risk of depleting any possible effective response to infection. For this reason, carbapenem-resistant A. baumannii is classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as a critical priority for research and development of new and effective antibiotic treatments.

## *Escherichia coli*

*E. coli* is part of the normal flora in the intestine in humans and animals. Nevertheless, it is also the most frequent cause of community and hospital-acquired urinary tract infections (including infections of the kidney), the most frequent cause of bloodstream infection at all ages, it is associated with intra-abdominal infections such as peritonitis, and with skin and soft tissue infections due to multiple microorganisms, and it is a cause of meningitis in neonates. *E. coli* is also one of the leading causes of foodborne infections worldwide. Many infections with *E. coli* originate from the gut of the person affected (auto-infection), but strains with some disease-causing properties (especially those that cause gastro-intestinal disease) or AMR can be also transmitted from animals, through the food chain. Spread between individuals is also possible.

Resistance in *E. coli* develops either through mutation, as for fluoroquinolone resistance, or by acquisition of mobile genetic elements, as for penicillins and third-generation cephalosporin resistance. Resistance to third-generation cephalosporins is mainly conferred by enzymes known as extended-spectrum beta-lactamases (ESBLs) and *E. coli* strains that have ESBLs are generally also resistant to several other antibacterial drug classes. In addition, because quinolones are probably one of the most widely used groups of antibacterial drugs for the treatment of urinary tract infections, for which *E. coli* is the most common cause, resistance to this class may be indicative of resistance to one of the last available oral treatment options, particularly in low-resources settings.

Carbapenems often remain the only available treatment option for severe infections, although carbapenem resistance in *E. coli* is an emerging threat and is mediated by a range of carbapenemases, which may confer resistance to virtually all available beta-lactam antibacterial drugs.

Colistin is used with increasing frequency, where available, for otherwise pan-resistant Gram-negative nosocomial infections, and acquired colistin resistance is still rare in most countries that have the ability to monitor it. However, of particular concern is the plasmid-mediated resistance to colistin (mediated by mcr genes), which was first described in *E. coli* isolated from food animals in China and subsequently found in clinical isolates from hospitalised patients in various parts of the world.

Carbapenem- and 3rd-generation cephalosporin-resistant strains of Enterobacteriaceae (the bacterial family that includes *E. coli*) are classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as critical priorities for research and development of new and effective antibiotic treatments.

## *Klebsiella pneumoniae*

Bacteria of the species *K. pneumoniae* are frequent colonisers of the gut in humans, particularly those with a history of hospitalisation. The majority of human infections caused by *K. pneumoniae* are health-care associated. Infections include urinary tract infections, lower respiratory tract infections, and bloodstream infections [75].

Resistance in *K. pneumoniae* develops either through mutation, as for fluoroquinolone resistance, or by acquisition of mobile genetic elements. *K. pneumoniae* carries a resistance gene (chromosome located beta-lactamase) that naturally renders penicillins with an extended spectrum ineffective. Resistance to other widely used and available oral antibacterial drugs such as co-trimoxazole and fluoroquinolones has emerged and spread globally [20].

The high proportions of cephalosporin resistance in the species (mediated by ESBLs or acquired AmpC enzymes) also means that treatment for verified or suspected severe *K. pneumoniae* infections in many situations has to rely on carbapenems, if available. However, *K. pneumoniae* is today the main cause of infections caused by carbapenem-resistant bacteria worldwide. All of the most important genes that can confer carbapenem resistance (via carbapenemase production) have been detected in strains of *K. pneumoniae*, thereby rendering almost all available treatment options ineffective.

Of even greater concern is that infections with carbapenem-resistant strains need to be treated with the last-resort drugs tigecycline or colistin, which are not only less effective but also not widely available and for many patients infected with these bacteria there are no clinically effective treatments.

Carbapenem- and 3rd-generation cephalosporin-resistant strains of Enterobacteriaceae (the bacterial family that includes *Klebsiella* spp.) are classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as critical priorities for research and development of new and effective antibiotic treatments.

## *Neisseria gonorrhoeae*

*N. gonorrhoeae* is the bacterium that causes gonorrhoea (these bacteria are also known as gonococci). Gonorrhoea is an acute sexually transmitted infection of the reproductive tract that may be symptomatic or asymptomatic. If untreated, or inappropriately treated, this infection can result in severe complications, including genital and reproductive tract inflammation and damage, and infertility. *N. gonorrhoeae* can also be transmitted sexually to infect other anatomic sites such as the pharynx and the rectum. Infection in pregnant women can result in infections in the new-born baby, including eye infections, which may lead to blindness [20].

*N. gonorrhoeae* is evolving into a superbug with resistance to previously and currently recommended antimicrobials for treatment of gonorrhoea. Given the global nature of gonorrhoea, the high rate of usage of antimicrobials, suboptimal control and monitoring of AMR and treatment failures, slow update of treatment guidelines in most geographical settings, and the extraordinary capacity of the gonococci to develop and retain AMR, it is likely that the global problem of gonococcal AMR will worsen in the foreseeable future and that the severe complications of gonorrhoea will emerge as a silent epidemic [76].

Third-generation cephalosporins, which are the last remaining options for empiric monotherapy, are now recommended as the first-line treatment regimen for gonococcal infections. There is currently no ideal alternative to the third-generation cephalosporins, and there are very few new treatment options in the drug development pipeline. In this context, alarmingly, several countries have reported treatment failures with oral cephalosporins, and there are now verified reports of treatment failure with parenteral cephalosporins in patients with pharyngeal gonorrhoea.

*N. gonorrhoeae* resistant to 3rd generation cephalosporins and fluoroquinolones is classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as a high priority for research and development of new and effective antibiotic treatments.

## *Salmonella* spp.

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

Most *Salmonella* strains cause gastroenteritis, while some strains, particularly *Salmonella enterica* serotypes Typhi and Paratyphi, are more invasive and typically cause enteric fever.

Since 1989, multidrug-resistant strains of *Salmonella* spp. (resistant to chloramphenicol, ampicillin, and cotrimoxazole) have emerged and

expanded worldwide. Evolution of antibacterial resistance in non-typhoidal *Salmonella* spp. (NTS) varies between different serotypes of NTS, and is significant in some of them. As a result, fluoroquinolones have been suggested as the drugs of choice for the treatment of the enteric fever caused by species of NTS resistant to first-line antibiotics [77].

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

Fluoroquinolone-resistant *Salmonella* spp. are classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as a high priority for research and development of new and effective antibiotic treatments

## *Shigella* spp

*Shigella* species are a major cause of diarrhoea and dysentery throughout the world. These bacteria are transmitted by ingestion of contaminated food or water, or through person-to-person contact. Shigellosis is primarily a disease of resource-poor and crowded communities that do not have adequate sanitation or safe water. *Shigella* spp. is never part of the normal intestinal flora. Most patients recover without complications within 7 days, but shigellosis can be a life-threatening or fatal disease, particularly in children.

*Shigella* spp. strains used to be susceptible to cotrimoxazole. However, as resistance has emerged to this antimicrobial, treatment recommendations have shifted to ciprofloxacin or azithromycin. Of growing concern is multi-drug resistance, and in particular the increasing rate of resistance to ciprofloxacin reported for *Shigella* spp. isolates from Asian and African regions. Furthermore, resistance is emerging to recommended second-line antimicrobial drugs, such as the third-generation cephalosporin ceftriaxone and the macrolide azithromycin [78]. For this reason, the gaps in surveillance data at a national level are worrying and raise the question as to whether representative local data are available to inform treatment guidelines.

Fluoroquinolone-resistant *Shigella* spp. are classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as a medium priority for research and development of new and effective antibiotic treatments.

## *Staphylococcus aureus*

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

When penicillin was first introduced in the 1940s, it was an effective treatment for *S. aureus* infections, but resistance had already developed within a few years of its introduction. This resistance is mediated by the production of a beta-lactamase that inactivates drugs such as penicillin, ampicillin, and amoxicillin. Consequently, beta-lactamase-stable drugs as well as beta-lactamase inhibitors that could be combined with the antibacterial drugs were developed. However, strains of *S. aureus* have become resistant to these penicillinase-stable antibacterial drugs by acquiring a novel gene that encodes a novel penicillin-binding protein; these strains are termed meticillin-resistant *S. aureus* (MRSA).

Initially, MRSA was mainly a problem in health-care-associated infections, but during the past decade, community-acquired MRSA has increased significantly in several countries. Fortunately, many of these community-acquired MRSA strains remain susceptible to several non-beta-lactam antibiotics, whereas many health-care-associated MRSA infections are caused by difficult-to-treat multi-drug resistant strains. This may also be the case for prophylaxis in orthopaedic and many other surgical procedures. Second-line drugs needed to treat or prevent MRSA infections are more expensive. The treatment of last resort has been glycopeptides such as vancomycin and teicoplanin, which can only be given by injection and may need careful monitoring to avoid adverse side-effects. There is a clear increase in mortality, use of health-care resources, and additional costs associated with MRSA.

Meticillin-resistant and vancomycin-intermediate or -resistant *Staphylococcus aureus* are classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as a high priority for research and development of new and effective antibiotic treatments.

# *Streptococcus pneumoniae*

*S. pneumoniae* is the leading cause of community-acquired pneumonia worldwide, which is among the leading causes of death of children younger than 5 years. Other diseases caused by *S. pneumoniae* include common mild and self-limiting infections, such as acute otitis media, but also invasive disease with high mortality, such as meningitis. Among the bacterial causes of meningitis, *S. pneumoniae* is associated with the highest case-fatality rate and is the most likely to leave survivors with permanent residual symptoms. The clinical burden of pneumococcal infection is concentrated among the oldest and youngest sections of the population.

Resistance to beta-lactam antibacterial drugs in clinical isolates of *S. pneumoniae* occurs by acquiring substantial changes (known as mosaics) in the genes coding for the penicillin-binding proteins. Pneumococci carry a variety of virulence factors that facilitate adherence to, and transcytosis of, epithelial cells, including a polysaccharide capsule preventing phagocytosis by the host's immune cells. More than 90 different capsular serotypes are known, differing in virulence, prevalence, and extent of drug resistance. Interestingly, serotypes most frequently involved in pneumococcal disease or colonisation in infants are also most frequently associated with AMR. The successive acquisition of mosaicism in multiple penicillin-binding protein genes results in increasing minimum inhibitory concentrations for penicillin and the other beta-lactam drugs. Different clinical breakpoints exist depending on the site of the *S. pneumoniae* infection (meningitis, bloodstream, and lungs) as well as dosing regimens.

When penicillin was introduced, it dramatically changed the outcome for patients with pneumococcal pneumonia and concomitant bloodstream infection from a case–fatality rate of about 90% to a survival rate of about 90%. Resistance has been linked to worse clinical outcomes in patients with pneumococcal meningitis, but the clinical implications for patients with bloodstream infections caused by *S. pneumoniae* strains with reduced susceptibility to penicillin are less clear and for this reason, more data are needed.

Penicillin-non susceptible *S. pneumoniae* is classified by the WHO Priority Pathogens List of antibiotic-resistant bacteria as a medium priority for research and development of new and effective antibiotic treatments.

# ANNEX II: Pathogen-antimicrobial combination under GLASS surveillance

| Pathogen | Antibacterial class | Antibacterial agents that may be used for AST[a,b] |
|---|---|---|
| *Escherichia coli* | Sulfonamides and trimethoprim | Co-trimoxazole |
| | Fluoroquinolones | Ciprofloxacin or levofloxacin |
| | Third-generation cephalosporins | Ceftriaxone, cefotaxime, or ceftazidime |
| | Fourth-generation cephalosporins | Cefepime |
| | Carbapenems[c] | Imipenem, meropenem, ertapenem, or doripenem |
| | Polymyxins | Colistin |
| | Penicillins | Ampicillin |
| *Klebsiella pneumoniae* | Sulfonamides and trimethoprim | Co-trimoxazole |
| | Fluoroquinolones | Ciprofloxacin or levofloxacin |
| | Third-generation cephalosporins | Ceftriaxone, cefotaxime, or ceftazidime |
| | Fourth-generation cephalosporins | Cefepime |
| | Carbapenems[c] | Imipenem, meropenem, ertapenem, or doripenem |
| | Polymyxins | Colistin |
| *Acinetobacter* spp. | Tetracyclines | Tigecycline or minocycline |
| | Aminoglycosides | Gentamicin and amikacin |
| | Carbapenems[c] | Imipenem, meropenem, or doripenem |
| | Polymyxins | Colistin |
| *Staphylococcus aureus* | Penicillinase-stable beta-lactams | Cefoxitin[d] |
| | Penicillins | Oxacillin |
| Streptococcus pneumoniae | Penicillins | Oxacillin[e] |
| | Penicillins | Penicillin G |
| | Sulfonamides and trimethoprim | Co-trimoxazole |
| | Third-generation cephalosporins | Ceftriaxone or cefotaxime |
| *Salmonella* spp. | Fluoroquinolones | Ciprofloxacin or levofloxacin |
| | Third-generation cephalosporins | Ceftriaxone,cefotaxime or ceftazidime |
| | Carbapenems[c] | Imipenem, meropenem, ertapenem or doripenem |
| *Shigella* spp. | Fluoroquinolones | Ciprofloxacin or levofloxacin |
| | Third-generation cephalosporins | Ceftriaxone, cefotaxime or ceftazidime |
| | Macrolides | Azithromycin |

| Pathogen | Antibacterial class | Antibacterial agents that may be used for AST[a,b] |
|---|---|---|
| Neisseria gonorrhoeae | Third-generation cephalosporins | Cefixime |
| | Third-generation cephalosporins | Ceftriaxone |
| | Macrolides | Azithromycin |
| | Aminocyclitols | Spectinomycin |
| | Fluoroquinolones | Ciprofloxacin |
| | Aminoglycosides | Gentamicin |

a. The listed substances are priorities for surveillance of resistance in each pathogen, although they may not be first-line options for treatment. One or more of the drugs listed may be tested.
b. One or more of the drugs listed may be tested in countries. S, I, R and nominator and denominator data for each shall be reported separately.
c. Imipenem or meropenem is preferred to represent the group when available.
d. Cefoxitin is a surrogate for testing susceptibility to oxacillin (methicillin, nafcillin); the AST report to clinicians should state susceptibility or resistance to oxacillin.
e. Oxacillin is a surrogate for testing reduced susceptibility or resistance to penicillin; the AST report to clinicians should state reduced susceptibility or resistance to penicillin.

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