Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report

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Contents

Foreword

The WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) was launched in 2015 to foster surveillance of antimicrobial resistance (AMR) and antimicrobial consumption and use (AMC/U) globally to inform strategies to contain AMR.

Since its launch, GLASS has expanded in scope and coverage and as of May 2021, 109 countries and territories worldwide have enrolled in GLASS. A key new component in GLASS is the inclusion of antimicrobial consumption (AMC) surveillance at the national level highlighted in this fourth GLASS report.

GLASS is comprised of several technical modules. These include routine surveillance activities on AMR and AMC, focused surveillance of emerging resistance and AMR in *Candida* spp., and studies and surveys to estimate AMR burden and related drivers. GLASS is also the data source of the new Sustainable Development Goals (SDGs) AMR indicator: proportion of bloodstream infections (BSIs) due to *Escherichia coli* resistant to 3rd generation cephalosporins and methicillin-resistant *Staphylococcus aureus* (MRSA).

The fourth GLASS report summarizes the 2019 data reported to WHO in 2020. It includes data on AMC surveillance from 15 countries and AMR data on 3 106 602 laboratory-confirmed infections reported by 24 803 surveillance sites in 70 countries, compared to the 507 923 infections and 729 surveillance sites reporting to the first data call in 2017.

This report highlights an important difference in reported rates of BSIs caused by *E. coli* resistant to 3rd generation cephalosporins and MRSA, the SDGs indicators, between LMICs and HICs. The higher rates in LMICs are of concern and need to be investigated. Moreover, the very large discrepancy in the numbers of tested patients could indicate inappropriate access to care in LMICs and a related selection bias.

Most countries reported high rates of AMR in bloodstream, urinary and gastroenteric infections. Of note, high rates of resistance to last resort antibiotics, such as carbapenems, or first-line drugs, such as co-trimoxazole, were reported. Some countries reported high level of resistance to first-line empirical treatment in *N. gonorrhoeae*, which warrants further analysis to inform guidelines.

The report also describes developments over the past years in other AMR surveillance programmes led by WHO, including resistance to anti-human immunodeficiency virus and anti-tuberculosis medicines, antimalarial drug efficacy.

In a short period of time GLASS has made notable achievements in promoting national surveillance systems and data sharing according to global standards. However, limitations and gaps of the system must be addressed. In order to inform and guide further GLASS development, the *"3rd High level technical consultation and meeting on surveillance of antimicrobial resistance and use for concerted actions"* took place in April 2021, hosted by the Ministry of Health and Social Affairs of Sweden and the Ministry of Health and Welfare of the Republic of Korea, co-sponsored by the WHO. During the consultation it was unanimously agreed that, while continuing to strengthen quality routine surveillance, complementary approaches such as surveys are needed to address limitations and ensure all countries will be enabled to generate representative quality data.

GLASS next steps will focus on improving data representativeness and quality, assessing the burden of AMR, expand AMR and AMC surveillance, improve the use of surveillance data, and facilitate the AMR surveillance linkages between the human, animal and environmental sector. GLASS continues benefitting from the expertise of WHO AMR Surveillance and Quality Assessment Collaborating Centres Network and the backing of regional AMR and AMC surveillance networks, which represent important pillars for advancing AMR surveillance globally. Together with partners, the WHO three-level network plays a key role in promoting peer support for capacity building and identifying ways to overcome difficulties

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Abbreviations and Acronyms

AMC	Antimicrobial consumption
AMR	Antimicrobial resistance
AMU	Antimicrobial use
AST	Antimicrobial susceptibility testing
ATC/DDD	Anatomical therapeutic chemical/defined daily dose (system)
AWaRe	Access, Watch, Reserve
BSI	Bloodstream infection
CAESAR	Central Asian and European Surveillance of Antimicrobial Resistance
CDC	Centers for Disease Control and Prevention
CLSI	Clinical and Laboratory Standards Institute
COVID-19	Coronavirus disease 2019
DDD	Defined daily dose
DS/R	Decreased susceptibility or resistance
EARS-Net	European Antimicrobial Resistance Surveillance Network
ECDC	European Centre for Disease Prevention and Control
EGASP	Enhanced Gonococcal Antimicrobial Surveillance Programme
EQA	External quality assessment
ESAC-Net	European Surveillance of Antimicrobial Consumption Network
ESBL	Extended-spectrum beta-lactamase
EUCAST	European Committee on Antimicrobial Susceptibility Testing
FAO	Food and Agriculture Organization of the United Nations
GAP-AMR	Global Action Plan on Antimicrobial Resistance
GASP	Gonococcal Antimicrobial Surveillance Programme
GLASS	Global Antimicrobial Resistance and Use Surveillance System
GLASS-EAR	GLASS-Emerging Antimicrobial Resistance Reporting
GMS	Greater Mekong sub-region
HIC	High-income countries
HIV/AIDS	Human immunodeficiency virus/acquired immune deficiency syndrome
Hr-TB	Isoniazid-resistant TB
IHR	International Health Regulations (2005)
IQR	Interquartile range
KOICA	Korean International Cooperation Agency
LICs	Low-income countries
LMICs	Lower middle-income countries
MDR-TB	Multidrug-resistant TB
MIC	Minimum inhibitory concentration
MRSA	Methicillin-resistant *Staphylococcus aureus*
NRL	National reference laboratory
OIE	World Organisation for Animal Health
PAHO	Pan American Health Organization
PDR	Pan-drug-resistant
PPS	Point prevalence survey
Pre-XDR-TB	Pre-extensively drug-resistant TB
ReLAVRA	Latin American Network for Antimicrobial Resistance Surveillance (Red Latinoamericana de Vigilancia de la Resistencia a los Antimicrobianos)
RIS	Resistant, I[1], susceptible
RIVM	The Netherlands National Institute for Public Health and the Environment
RR	Rifampicin-resistant
SDGs	Sustainable Development Goals
TB	Tuberculosis
TrACSS	Tripartite AMR Country Self-assessment Survey
UMICs	Upper middle-income countries
UNEP	United Nations Environment Programme
UTI	Urinary tract infection
WAAW	World Antibiotic Awareness Week
WHO	World Health Organization
WPRACSS	Western Pacific Antimicrobial Consumption Surveillance System

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

1 At the beginning of 2019, EUCAST changed the definitions of the 'S', 'I' and 'R' susceptibility categories where 'I' is now defined as "Susceptible, increased exposure", while the Clinical and Laboratory Standards Institute keeps the 'Intermediate' category.

Summary

Launched by the World Health Organization (WHO) in 2015 to support the strengthening of the antimicrobial resistance (AMR) evidence base, the Global Antimicrobial Resistance and Use Surveillance System (GLASS) is the first system that enables harmonized global reporting of official national AMR and antimicrobial consumption (AMC) data.

By using these data, GLASS aims to offer a synergized approach to presenting surveillance data and identifying the drivers for AMR. Importantly, GLASS also provides support and guidelines to assist countries and regions to build capacity and take corrective actions when appropriate.

GLASS has evolved since its launch when the only available technical module was the monitoring of AMR in common bacterial pathogens (GLASS-AMR). Current technical modules include surveillance activities built on routinely available data, focused surveillance activities aimed at generating information for specific purposes, and studies and surveys to estimate AMR burden and related drivers (e.g., antimicrobial use) based on countries' needs. The aims of this fourth GLASS report are to:

- describe the status of development of GLASS activities;
- summarize the results of the 2020 AMR and AMC data calls from participating countries and their data limitations;
- summarize WHO AMR-related activities globally and regionally.

As of 30 April 2021, 109 countries or territories are enrolled in GLASS, comprising 107 in the GLASS-AMR module and 19 in the GLASS-AMC module (two countries are enrolled only in GLASS-AMC).

The report highlights the new technical module on AMC surveillance, GLASS-AMC (Section 2.1), which provides a common, standardized set of methodologies for measuring and reporting the consumption of antimicrobial medicines at country, regional and global level. AMC data are estimates derived from aggregated data sources ranging from the macro level, such as import and distribution, to the micro level, such as data on prescriptions and insurance reimbursements. Countries enrolled in GLASS-AMC are asked to provide two types of information: (1) national AMC consumption data from the previous year; and (2) data on the level of implementation of their surveillance system. WHO uses the anatomical therapeutic chemical (ATC)/defined daily dose (DDD) system as the basis for the classification of medicines and the calculation of medicine consumption estimates and expresses the quantities of antimicrobials in number of defined DDDs and the weight of antimicrobials in metric tonnes (t). The latter metric can also be used for comparison with AMC in the animal sector.

Data on AMC provide a basis for countries to understand the patterns and volume of antimicrobials consumed nationally and to support the development of guidelines and policies for the optimal use of antimicrobials, as well as regulations and interventions. The report summarizes key indicators at the implementation level of the national AMC surveillance systems of the 18 countries enrolled in GLASS-AMC as of December 2020. Specifically, 15 of the 18 countries, territories and areas enrolled in GLASS-AMC provided information on their AMC surveillance systems. Overall results show national surveillance systems in different implementation stages. More than half of the countries have surveillance objectives set, antimicrobials under surveillance specified, and source(s) of AMC data identified. These results are not yet representative of national AMC surveillance systems globally or regionally. However, this is the first attempt to monitor national AMC surveillance implementation globally and it allows to set a benchmark to monitor the implementation of national AMC surveillance systems over time.

GLASS-AMR (Section 2.2) captures information on the frequency of resistance among high-priority pathogens that cause infections in humans. Based on the rationale that the growth of a pathogen in selected specimens is a proxy for infection in the associated anatomical site, data on AMR are collected through a routine surveillance system, with collation of the sampling results of blood (*Acinetobacter* spp., *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella* spp., *Staphylococcus aureus* and *Streptococcus pneumoniae*), urine (E. *coli*, *K. pneumoniae*), stool (*Salmonella* spp., *Shigella* spp.) and cervical and urethral specimens (*Neisseria gonorrhoeae*) sent routinely to laboratories for clinical and public health purposes. The "population under surveillance" is defined as patients seeking care in health care facilities. Countries are also invited to report demographic and epidemiological variables in an aggregated format, such as age, gender, origin of infection (community versus hospital), and the number of tested patients.

By the end of the fourth AMR data call in August 2020, 94 countries were enrolled in the GLASS-AMR module, including 14 low-income (LICs), 28 lower-middle-income (LMICs), 17 upper-middle-income (UMICs), and 35 high-income countries (HICs), territories and areas across all WHO regions. Of these, 82 countries, territories or areas reported to GLASS during the data call. Twelve provided information on the status of their national AMR surveillance systems, four reported AMR data for 2019, and 66 provided both information on the current status of their national surveillance system and AMR data for 2019. Information on a total of 3 124 982 laboratory-confirmed infections caused by pathogens under surveillance was submitted by the 70 countries that provided data. These concerned mainly urinary tract infections (UTIs) (83%), followed by bloodstream infections (BSIs) (16%). Antimicrobial susceptibility testing (AST) was performed in 3 030 413 isolates (91%). Twenty-five (36%) countries, territories and areas also provided information on the population tested with suspected infections (for example, the number of patients from which a blood sample was taken, independent of bacterial growth).

The reported median resistance rate for the two Sustainable Development Goals (SDG) AMR indicators monitoring the proportion of AMR in bloodstream infections (BSIs) were 36.6% (interquartile range [IQR] 17.5-58.3) for *E. coli* resistant to 3rd generation cephalosporins and 24.9% (IQR 11.4-42.7) for methicillin-resistant *S. aureus* (MRSA). Of note, the median rates of resistance were found to be higher in LMICs compared to HICs. This finding is concerning as it may imply that less-resourced countries may be more heavily affected by AMR, but it requires further assessment to investigate the reasons behind this difference, including a potential selection bias and data limitations in reported rates.

Data on other types of AMR in pathogens causing BSI, UTI, gastrointestinal and genital infections have been summarized. The overall reported median resistance rate for 3rd generation cephalosporins was found to be quite high (between 40-50%) for BSIs caused by *K. pneumoniae* and UTIs caused by both *E. coli* and *K. pneumoniae*. Notably, the high rates of resistance in pathogens causing BSIs against last resort antimicrobial drugs, such as carbapenems, are of great concern. The median carbapenem resistance of 65.48% in BSIs caused by *Acinetobacter* spp., an emerging pathogen causing hospital infections, depicts a dire scenario.

High AMR rates in the most frequent pathogens causing UTI have been reported. The median resistance reported for co-trimoxazole, a first line UTI treatment drug, was 54.4% (IQR 36.5-69.4) for *E. coli* and 43.1% (IQR 31.8-57) for *K. pneumoniae*; resistance against ciprofloxacin was found to be consistently high, with 43.1% (IQR 22.5-58.6) for *E. coli* and 36.4% (IQR 28.5-52.3) for *K. pneumoniae*. Similar results were found for levofloxacin, another fluoroquinolone monitored by GLASS for UTIs. Finally, the resistance level in *N. gonorrhoeae* to ceftriaxone, a 3rd generation cephalosporin, has surpassed 5% in four out of 21 reporting countries, thus precluding its use as a first-line treatment. Of note, resistance against cefixime, a 4th generation cephalosporin, has already been reported in two countries.

The observed rates of resistance suggest that it is extremely important to maintain the detection and characterization of the underlying resistance mechanisms in participating countries, as well as to correlate these rates with data on AMC and antimicrobial use (AMU) at the local level in order to plan actions to contain the spread of AMR. Global summaries of AMR data are shown in section 2.2.3 and the interactive visualization of AMR results by single countries, territories and areas is available on the WHO Global Health Observatory GLASS webpage (https://www.who.int/data/gho/data/themes/topics/global-antimicrobial-resistance-surveillance-system-(glass)).

GLASS-focused surveillance and special survey activities (Section 2.3-8) include the following components.

- GLASS Emerging Antimicrobial Resistance Reporting (EAR) for the timely detection, reporting, risk assessment and monitoring of emerging resistance.
- Surveillance of invasive fungal bloodstream infections caused by *Candida* spp. (currently being pilot tested).
- One Health[2] surveillance through the WHO integrated, multi-sectoral surveillance based on the extended-spectrum beta-lactamase (ESBL) *E. coli* Tricycle project. The project has been pilot tested in six LIC and LMICs and implemented in a further nine countries in 2020.
- The Enhanced Gonococcal Antimicrobial Surveillance Programme (EGASP) has been pilot tested in the Philippines and Thailand. Activities initiated in Cambodia in 2020 provided an unprecedented set of clinical data related to resistant *N. gonorrhoeae* and have allowed the finalization of the EGASP protocol.
- Point prevalence surveys (PPS) on AMU in hospitalized patients in 34 countries.
- Planned assessment of attributable mortality of AMR BSIs.

The report also describes developments over the past years in other surveillance programmes led by WHO (Section 3.1), including resistance to anti-human immunodeficiency virus (HIV) and anti-tuberculosis (TB) medicines, antimalarial drug efficacy, and environmental surveillance of AMR. It also reports on the annual activities of WHO Regional Offices (Section 3.2) related to AMR and AMC, thus highlighting the key roles of all levels of WHO in improving the understanding and control of AMR, as well as the unique synergistic role the Organization plays in fulfilling these objectives.

Since the GLASS launch in October 2015, several lessons have been learnt during the early implementation phase. It is now time to review and further develop GLASS by building upon these lessons. For this purpose, the Ministry of Health and Social Affairs of Sweden and the Ministry of Health and Welfare of the Republic of Korea hosted the *3rd High Level Technical Consultation and Meeting on Surveillance of Antimicrobial Resistance and Use for Concerted Actions* in April 2021 to inform the further development and implementation of GLASS. In the early implementation phase, GLASS has already collected an unequalled amount of information on AMR globally and regionally and continues to foster the development of national AMR surveillance systems. The next steps will seek to enhance data quality, completeness and representativeness, and provide estimates of the impact of AMR on human health.

2 'One Health' is an approach to designing and implementing programmes, policies, legislation, and research in which multiple sectors communicate and work together to achieve better public health outcomes. The areas of work in which a One Health approach is particularly relevant include food safety, the control of zoonoses, and combatting antibiotic resistance (https://www.who.int/news-room/q-a-detail/one-health).


SECTION
01

1. Introduction

1.1 WHO response to the emergence of antimicrobial resistance (AMR)

AMR is the presence of resistance to antimicrobial medicines in infectious agents, such as bacteria, viruses, fungi and parasites, and can be inherent or acquired by the inappropriate use of medicines. AMR in a wide range of infectious agents is a growing public health threat of significant concern to countries and to many sectors across the One Health[3] spectrum. There is increasing evidence of a growing spread of multidrug-resistant bacteria that cause common infections and are resistant to treatment with existing antimicrobial medicines. For this reason, the need to generate reliable and comparable global AMR data is paramount *(1–3)*.

WHO has been leading the response to AMR over the past two decades and its efforts led to the approval of the Global Action Plan on Antimicrobial Resistance (GAP-AMR) by the Sixty-eighth World Health Assembly in May 2015 *(4)*. In 2019, the Organization declared AMR as one of the top 10 global public health threats facing humanity in 2019 and added two specific AMR indicators to its 13th General Programme of Work (2019–2023): (i) bloodstream infections (BSIs) due to two specific pathogens; and (ii) trends in national consumption of antibiotics *(5)*. During the same year, upon the request of Member States, WHO proposed the inclusion of a new AMR indicator linked to target 3.D ("strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks") in the monitoring framework of the Sustainable Development Goals (SDGs). This indicator monitors the proportion of BSIs due to *Escherichia coli* resistant to 3rd generation cephalosporins and methicillin-resistant *Staphylococcus aureus* (MRSA) *(6)*.

WHO's core mandate is also to coordinate collaboration with key partners and other United Nations (UN) agencies to strengthen concerted actions to mitigate the impact of AMR, thus demonstrating its key role in building capacity to control AMR, advocating for evidence-based interventions, driving awareness and understanding, identifying priority areas of research, and developing global norms and standards *(7)*.

AMR is a complex phenomenon and an intersectoral approach is essential to harmonize human, animal, plant, and environmental policies and activities in order to fully understand the drivers and limit emergence in different ecosystems. In this regard, the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE) and WHO signed a memorandum of understanding on AMR in 2018 to cooperate as a "Tripartite" and to apply a One Health approach to combat health risks at the animal-human-ecosystem interface *(8)*. In 2021, the Tripartite successfully launched the One Health Global Leaders Group *(9)*, which includes the Director-Generals of the Tripartite organizations and the UN Environment Programme (UNEP), politicians and senior civil servants, civil society and the private sector, with the specific role to advocate for global action to address AMR. The Tripartite also developed a global AMR monitoring and evaluation framework within the Global Action Plan on AMR (GAP-AMR) and launched the "Tripartite AMR Country Self-assessment Survey (TrACSS)" to specifically address monitoring of the implementation of AMR national action plans *(10, 11)*. Four rounds of TrACSS have been completed so far (2016-17; 2017-18; 2018-19; 2019-20); the questionnaires used and results are available at: http://www.who.int/antimicrobialresistance/global-action-plan/database/en.

Together with partners, WHO is leading the global response to mitigate the impact of AMR on human health and development.

3 'One Health' is an approach to designing and implementing programmes, policies, legislation, and research in which multiple sectors communicate and work together to achieve better public health outcomes. The areas of work in which a One Health approach is particularly relevant include food safety, the control of zoonoses, and combatting antibiotic resistance (https://www.who.int/news-room/q-a-detail/one-health).

1.2 The role of surveillance in understanding AMR

Surveillance is the cornerstone for assessing the spread of AMR. It is essential for informing policies and interventions, including diagnostic laboratory capacity, stewardship programmes, supply chain management, and infection prevention and control. Surveillance is also an indispensable tool for monitoring new emerging patterns of resistance and for evaluating the effectiveness of local, national and global containment and mitigation strategies.

For decades, WHO has been leading surveillance activities to inform AMR epidemiology globally of drug-resistant infections in some specific diseases. High-quality data are available from 169 countries and territories for drug-resistant tuberculosis (TB), from 57 countries for resistance to drugs for human immunodeficiency infection (HIV) infection, and from 64 countries for antimalarial drugs. This represents most of the world population and most of the burden of high-impact infectious diseases. The status of and trends in resistance to drugs for these diseases are routinely published in disease-specific reports and peer-reviewed publications *(12)*.

Large regional AMR surveillance networks have been in place for more than 20 years. These include the European Antimicrobial Resistance Surveillance Network (EARS-Net) *(13)* since 1998, coordinated by the European Centre for Disease Prevention and Control (ECDC) in the European Union; the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network *(14)* since 2011 for countries not part of EARS-Net in the WHO European Region, a joint initiative of the WHO Regional Office for Europe, the European Society of Clinical Microbiology and Infectious Diseases, and the Dutch National Institute for Public Health and the Environment (RIVM); and the Latin American Network for Antimicrobial Resistance Surveillance (ReLAVRA) *(15)*, established in 1996 by the WHO/Region of the Americas/Pan American Health Organization (PAHO) Regional Office and partnering Member States.

The Global Antimicrobial Resistance and Use Surveillance System (GLASS) was launched in 2015 upon request by the Sixty-eighth World Health Assembly in resolution WHA68.7, with the aim to support the GAP-AMR, and specifically the GAP-AMR second objective, which is to strengthen knowledge through surveillance and research and to enhance existing activities *(16, 17)*.

1.2.1 Global Antimicrobial Resistance and Use Surveillance System (GLASS)

GLASS monitors progress in the implementation of national surveillance systems worldwide and fosters the standardized collection, analysis and sharing of official data on AMR and antimicrobial consumption (AMC), as well as information on key AMR epidemiological indicators. GLASS activities are grouped into several technical modules *(18)*. These modules comprise surveillance activities built on routinely available data (for example, patient samples collected for clinical purposes or national sales of antimicrobials) and focused surveillance activities aimed at generating information for specific purposes based on countries' needs. GLASS is also engaged in the design and implementation of surveys and studies aimed at helping countries to collect data on key AMR epidemiological indicators.

GLASS-AMC (Section 2.1) provides a standardized set of methods for measuring and reporting the consumption of antimicrobial agents at country level. GLASS-AMR (Section 2.2) provides a standardized approach to the collection, analysis and sharing of national AMR data in samples collected routinely for clinical purposes for a set of pathogens that cause common bacterial infections in humans. Both modules collect data on the implementation of respective national surveillance systems. The emerging AMR reporting module (GLASS-EAR) (Section 2.3) allows the timely detection, reporting, risk assessment and monitoring of emerging resistance. The initial focus of GLASS-FUNGI (Section 2.4) is on the surveillance of invasive fungal BSIs caused by *Candida* spp. The GLASS-One Health module (Section 2.5) is an integrated multi-sector surveillance based on the extended-spectrum beta-lactamase (ESBL) *E. coli* Tricycle project. The Enhanced Gonococcal Antimicrobial Surveillance Programme (EGASP) (Section 2.6) offers an enhanced approach to sentinel gonorrhoea surveillance of men with urethral discharge and suspected urogenital infections. Point prevalence studies on antimicrobial use (PPS-AMU) (Section 2.7) offer a method for surveys of antibiotic use at the hospital level, and the AMR burden module (Section 2.8) presents an approach for estimating the health impact of AMR.

National data are submitted to the GLASS online platform (https://extranet.who.int/glass/portal/). Launched by WHO in 2016, the platform is a common environment for entering, reporting, visualizing and extracting GLASS data. Through data visualization, countries can generate and export reports with graphic representations of their data and check their validity against several indicators.

GLASS and the regional networks, with the support of WHO Collaborating Centres, also contribute to building national laboratory capacities through technical support to primarily low-resource settings in the development and operation of national reference laboratories (NRL), such as external quality assessment (EQA), quality management, continuous training for performance of AMR testing, and the reporting and interpretation of AMR results. Several guidance documents have been recently developed to support laboratory functions. For example, in 2020, GLASS published "GLASS whole-genome sequencing for surveillance of antimicrobial resistance" and "GLASS guidance for national reference laboratories" *(19, 20)*.

1.2.1.1 GLASS revision

GLASS was designed to be implemented in five-year cycles, followed by revision and further development based on lessons learnt and best practices identified during each of these periods. The first phase, defined as 'early implementation' of GLASS, covered the period 2015–2019 *(21)*. The key objectives of this phase have been to launch the global surveillance system and provide guidance and technical support to countries on how to develop an effective national AMR surveillance system. From the first data call in 2017, in which 40 countries participated, GLASS has now enrolled more than 100 countries. It has secured strong commitment from participating countries and enjoys a close collaboration with AMR regional networks. GLASS data submission has encouraged the collection, analysis and presentation of standardized data generated from healthcare facilities, and countries that did not have an AMR surveillance system already in place have used the GLASS manual for early implementation to guide the development of the national system.

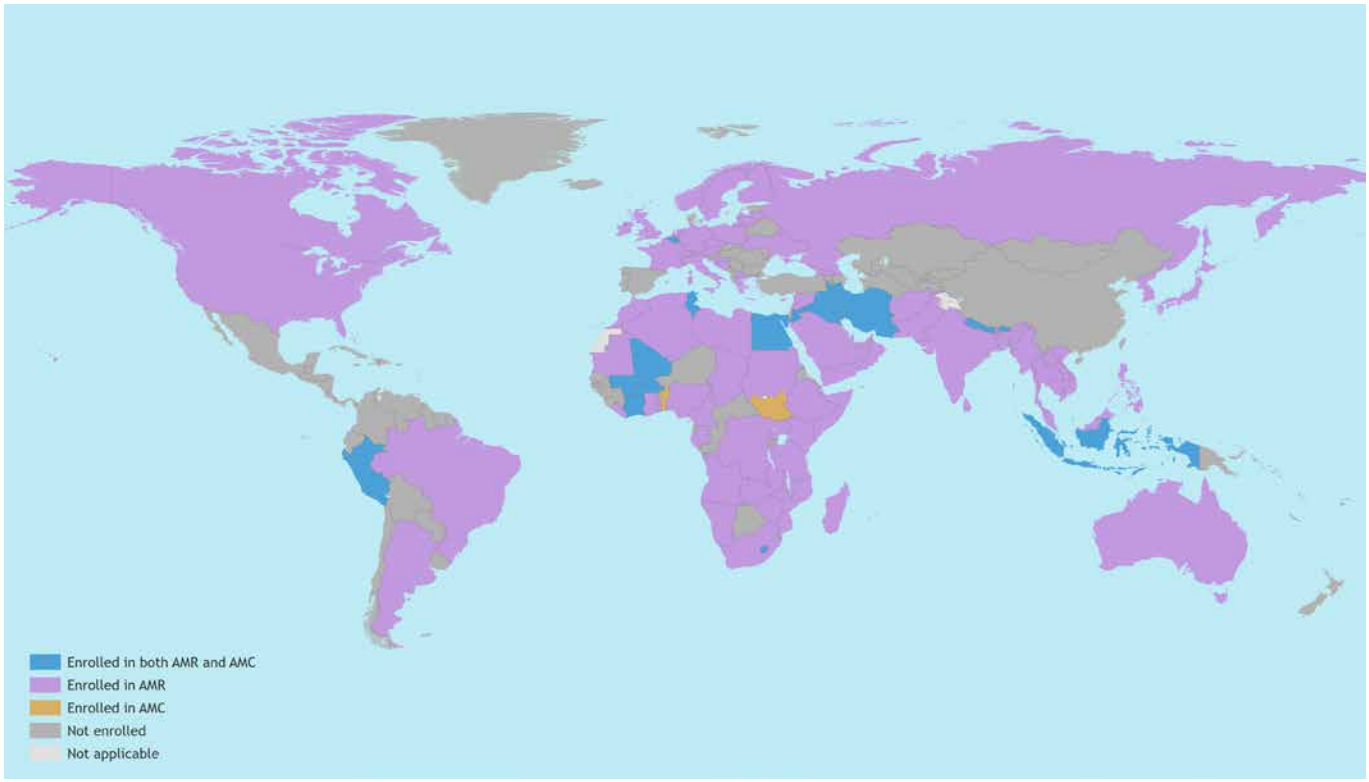
Consistently transparent in sharing the limitations intrinsic to routine-based surveillance systems, particularly those with a strong laboratory component, GLASS has continually improved, not only by including different activities, but also by actively seeking solutions to develop the evidence base for reliable and representative data to inform national and global AMR estimates.

The Ministry of Health and Social Affairs of Sweden and the Ministry of Health and Welfare of the Republic of Korea hosted the *3rd High level technical consultation and meeting on surveillance of antimicrobial resistance and use for concerted actions*, co-sponsored by WHO *(22)*. The objectives of the consultation and meeting were to: (1) obtain continued and sustained high-level commitment to build capacities needed for the national and global surveillance of AMR and use; (2) review GLASS performance, including achievements and shortcomings in relation to global needs; (3) discuss and agree on modifications and proposals for revision of the GLASS methodology; and (4) inform future directions and improvements of GLASS. To achieve these goals, an online consultation was held from September 2020 to March 2021. Building on the consultation, a four-day virtual meeting was held in April 2021. Participants were high-level/senior officers in ministries of health, and public health agencies or other bodies with technical experience and responsibility related to AMR or AMU/AMC surveillance. Other invited participants were representatives from the OIE, FAO, and other selected organizations and networks, WHO staff, representatives from the WHO AMR Surveillance and Quality Assessment Collaborating Centres Network, and representatives from the Governments of Sweden and the Republic of Korea.

Revision of the GLASS methodology presented during the consultation and the meeting was based on formal and informal feedback from GLASS national focal points and implementing partners, assessment missions, special initiatives (such as Northern GLASS), feedback from the UN Interagency Coordination Group on Antimicrobial Resistance working paper on surveillance and monitoring for AMU and AMR, and published scientific papers (23-26). The new GLASS-AMR Manual 2.0 is one of the outputs and will be finalized following feedback received from countries' representatives and partners during the consultation.

At 30 April 2021, 107 countries are enrolled in GLASS, ether in the AMR or AMC module (Fig. 1.1). The report emphasizes the AMC surveillance methodological approach, which was embedded in the GLASS framework in 2019. It also highlights the key role of WHO and GLASS in monitoring the presence and frequency of AMR globally and in identifying risk factors and drivers to guide policies, strategies, planning, and implementation.

Fig. 1.1. GLASS enrolment map at the 30 April 2021



The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: WHO, Global Antimicrobial Resistance and Use Surveillance System (GLASS)
Map Production: WHO GIS Centre for Health, DNA/DDI

World Health Organization


SECTION
02

2. GLASS technical modules: methods and summary results

2.1 GLASS-AMC

A crucial element of AMR control, also defined in the GAP-AMR, is the monitoring of AMU, both in terms of strengthening the surveillance and optimizing the use of antimicrobials. For this reason, WHO initiated the global programme on surveillance of AMC in 2016 and now integrated in the GLASS framework in 2020 *(18, 27)*. AMC is defined as the quantity of antimicrobials used by a population in a specific setting (for example, the community or hospital health care level) during a specific period of time (for example, days, months and year). These data are measured from aggregated data sources, such as import or wholesaler data, or aggregated health insurance data, or hospital pharmacy dispensing or procurement databases at the health care facility level, generally considered as a proxy estimate of AMU. This type of data provides no information on the patients who receive the medicines or why the antimicrobials are being used.

GLASS-AMC is built on and collaborates with existing international monitoring systems (Table 2.1), such as the European Surveillance of Antimicrobial Consumption Network (ESAC-Net) and the WHO Regional Offices for Europe and the Western Pacific (28, 29). This ensures standardization among global and regional initiatives and data exchanges between the different systems.

The core component of the "GLASS methodology for surveillance of national antimicrobial consumption", published in 2020, is the national AMC surveillance framework. It is built around well-established international classification and categorization systems, such as the anatomical therapeutic chemical (ATC)/ defined daily dose (DDD) system (Annex 1) and the "Access, Watch, Reserve" (AWaRe) categorization (Annex 2) *(30-32)*. WHO has also published the "GLASS guide for national surveillance systems for monitoring antimicrobial consumption in hospitals" and the "WHO methodology for point prevalence survey on antibiotic use in hospitals" to complement the work done at national level *(33, 34)*.

Table 2.1. AMC regional networks

ORGANIZATION/COUNTRY	NETWORK/SURVEILLANCE SYSTEM	DESCRIPTION
ECDC	European Surveillance of Antimicrobial Consumption Network (ESAC-Net)	Collects and reports data on consumption of systemic antimicrobials in the community and hospital sector from European Union countries, Iceland, and Norway
WHO Regional Office for Europe	Antimicrobial Medicines Consumption Network	Established in 2011, this surveillance system collects and reports data from 19 non-European Union countries and areas. Efforts are coordinated with the ECDC to provide comparability and a pan-European overview of AMC trends.
WHO Regional Office for the Western Pacific	Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS)	Established in 2020, it supports Member States in the implementation and further development of AMC and AMU monitoring at national level and provides a regional platform for countries to understand their own consumption patterns.

The GLASS-AMC provides:

1. At the national level

- A methodology that can be integrated in the package of tools to assist the national strategy on optimizing AMU (for example, national action plans on AMR).
- A methodology that can produce information on quantities and types of consumed antimicrobials to guide the decisions of policy-makers and prescribers and thus monitor the impact of national actions to optimize the access and rational use of antimicrobials.

2. At the regional and global level

- A methodology common to all countries for the collection, analysis, and reporting of national AMC data.
- Reliable and comparable national consumption data over time and between countries.
- Comparable data with animal and agricultural consumption data.

GLASS-AMC surveillance at national level focuses only on antimicrobials for systemic use and topical antimicrobials are excluded (Table 2 .2). WHO has defined a core set of antimicrobials that all countries should include in their surveillance programme. In addition, the programme includes an optional list of antimicrobials that countries may include, according to local needs and resources. Furthermore, countries may include extra antimicrobial medicines in their national programme.

Table 2.2. Classes of antimicrobials listed as core or optional by the WHO surveillance programme

ANTIMICROBIAL CLASS	ATC	MONITORING
Antibacterials for systemic use	J01	Core
Antibiotics for alimentary tract	A07AA	
Nitroimidazole derivatives for protozoal diseases	P01AB	
Antifungals	J02	Optional
Antimycotics	D01BA	
Antivirals	J05	
Antimycobacterials for treatment of TB	J04A	
Antimalarials	P01B	

Consumption data can be retrieved at different levels of the value chain of medicines (Fig. 2.1) and from several sources. For each of the five levels, the most common sources are listed in Annex 3.

Countries need to understand the nature, scope and limitations of data collection from each of these sources to avoid the under- or overestimation of AMC. The GLASS-AMC methodology summarizes some of the strengths and weaknesses for each of these data sources *(30)*.

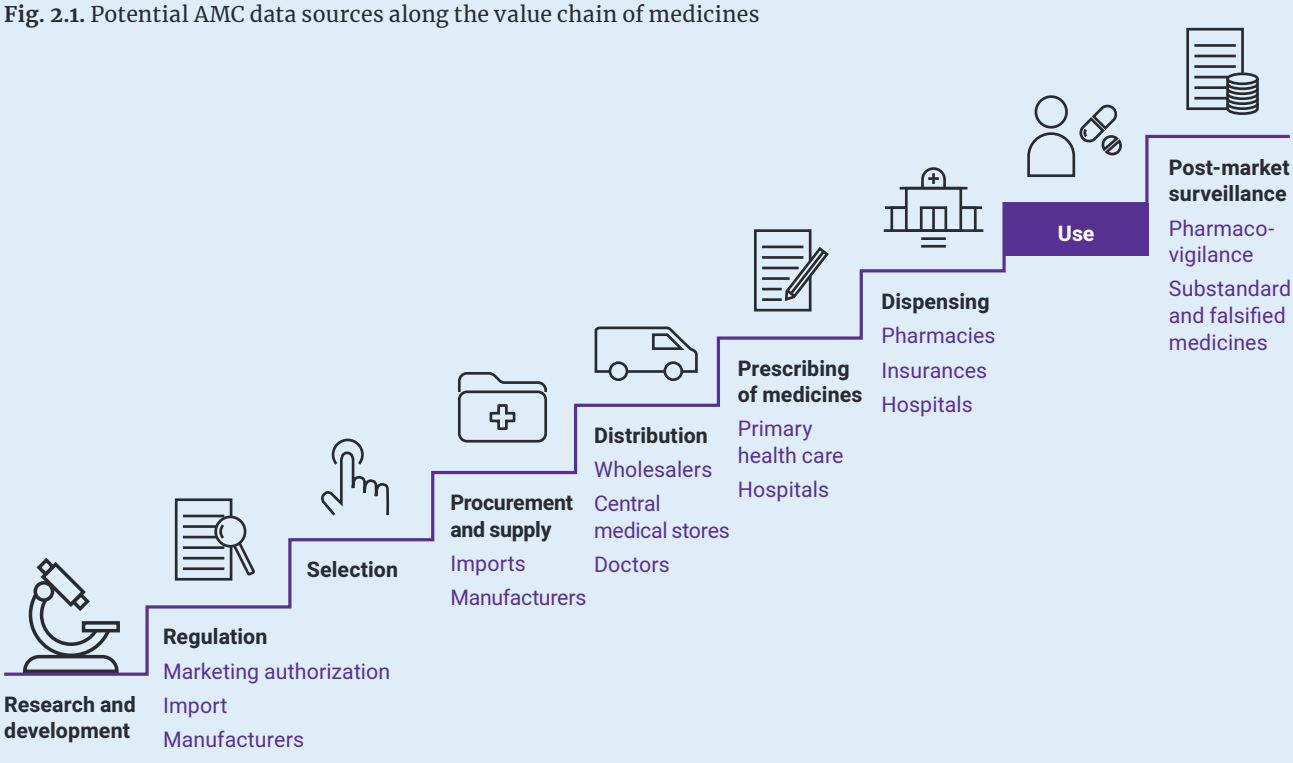
AMC surveillance includes both the public and private health care sectors, as well as the hospital and community health care levels, and it is possible to collect data for one or both sectors. Three data elements should be collected to ensure that AMC is correctly quantified, adjusted for the population to which the data apply, and that results are adequately interpreted.

1. **A register of the antimicrobials targeted by the surveillance system.** The register is the list of all antimicrobial medicinal products covered by the surveillance system in the country (for example, products registered as part of the marketing authorization).
2. **Package data.** The total number of packages for each product listed in the register that are consumed by the population in a defined health care setting during a defined period.
3. **The population to which the data apply.** For national estimates of consumption, the appropriate population will be the total national population (all age and gender groups combined).

Contextual information allows to interpret the data reported. It should include the sources of data used, the health care levels and sectors involved, the antimicrobial agents included in the surveillance, and whether any specific groups of patients or facility types have been excluded from the calculations (for example, nursing homes, day care centres, psychiatric facilities or rehabilitation units). Importantly, countries should provide coverage of the national population of their national surveillance system.

The two main metrics used to describe the volume of antimicrobials consumed are the number of DDD and the weight of the antibiotic substances in metric tonnes (t), with the latter metric used for comparison with AMC in the animal sector. The total number of packages or units sold of a specific product or therapeutic group level can also be used to provide important information on antimicrobial products and market shaping, which allows an additional analysis. For comparative purposes, these data are usually adjusted for population size.

Fig. 2.1. Potential AMC data sources along the value chain of medicines



Antibiotic consumption is generally summarized using the following key indicators.

4. Quantity of antibiotics as DDD per 1000 inhabitants per day for total consumption and by pharmacological subgroup.
5. Quantity of antibiotics as weight in tonnes for total consumption and by pharmacological subgroup.
6. Relative consumption of antibiotics as a percentage of the total consumption by route of administration (oral, parenteral, rectal and inhaled) and AWaRe categories.
7. List of the most frequently used antibiotic substances comprising 75% of the total drug utilization (DU75%), stratified by route of administration and DU75%.

The latest version of the ATC/DDD should be used to calculate the DDD; the consumption per population is obtained using the UN population figures and coverage figures provided by countries.

2.1.1 Participation and reporting to GLASS-AMC

Since the integration in 2020 of the global programme to monitor AMC in GLASS, 19 countries, territories and areas have enrolled in GLASS-AMC (Table 2.3). These include a mix of countries, territories and areas in different stages of economic development (three LICs, eight LMICs, six UMICs, and two HICs). Enrolled countries represent five WHO regions (six from the African Region, one from the Region of the Americas/PAHO, six from the Eastern Mediterranean Region, one from the European Region, and five from the South-East Asia Region). Low or null participation in GLASS-AMC for some regions was expected due to the ongoing harmonization processes with existing regional AMC surveillance networks.

Each year, countries enrolled in GLASS-AMC are invited to report:

- national AMC data from the previous calendar year through the GLASS IT platform;
- the implementation status of the national AMC surveillance system.

Countries can enrol in GLASS at any stage of development of their surveillance system and can start reporting AMC data at later stages *(35)*. In 2020, no national AMC data were collected for this GLASS report. However, 18 countries enrolled in GLASS-AMC reported on the status of their surveillance systems. This information is collected on an annual basis through a questionnaire. The aim is to monitor progress on AMC surveillance in countries, as well as at global level, in order to identify any technical support that may be needed by countries. The data provided are analysed annually. Together with the number of enrolled countries, the data allow monitoring of the changes in the level of implementation of national AMC surveillance programmes over time. Aggregated results are provided by WHO region in Section 2.1.2.

Table 2.3. Countries, territories and areas enrolled in GLASS-AMC as of December 2020

INCOME LEVEL[a]			
LOW	LOWER-MIDDLE	UPPER-MIDDLE	HIGH
Burkina Faso	Benin	Indonesia	Belgium
Mali	Bhutan	Iran (Islamic Republic of)	Kuwait
South Sudan	Côte d'Ivoire	Iraq	
	Egypt	Jordan	
	Lesotho	Maldives	
	Nepal	Peru	
	Timor-Leste		
	Tunisia		

a World Bank Country and Lending Groups (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).

AMC contextual data are collected through an online questionnaire that is part of the GLASS-AMC platform and provides general information on the uploaded data. The questionnaire addresses five areas: ATC classes reported; data sources used (for example, importation, central drug store and pharmacies); proportion of the population covered by the data; level of care (community versus hospital) and health care sectors (public versus private) covered by the data; and shortage of antimicrobials. AMC data submission can also take place through the IT platform. The process has a well-established flow that involves both the countries and the GLASS team. If there are errors, countries can request withdrawal of data that have been previously approved and can re-submit data with the correct figures at any time. WHO will only publish data approved by countries.

The advancement of global surveillance on AMC from its early implementation phase (2016-2018) to the recent incorporation into GLASS in 2020 has brought a new requirement for Member States involving a two-step process of reporting data to GLASS-AMC. The first step is enrolment in GLASS-AMC as a formal prerequisite for the second step related to the submission of AMC data during annual GLASS AMC data calls. In parallel, efforts have been made to harmonize the annual data transfer from existing official regional AMC surveillance networks (that is, the WHO European Region AMC network, ESAC-Net, WPRACSS) to GLASS AMC, thus ensuring standardization and avoiding any duplication in national reporting to WHO.

2.1.2 Implementation status of national AMC surveillance systems

Of the 18 countries, territories and areas enrolled in GLASS-AMC from the African, Americas/PAHO, Eastern Mediterranean and South-East Asia Regions, 15 provided information on their AMC surveillance systems. The indicators on the implementation status of AMC surveillance systems are summarized as country absolute numbers and proportions, and listed by region and globally for the four implementation components: (i) coordination; (ii) structure; (iii) data availability and use; and (iv) coverage and granularity of the national AMC surveillance system. For the first three components, proportions are calculated with the total number of GLASS-AMC enrolled countries as the denominator (n=15). For the coverage and granularity indicator, proportions are calculated using only the GLASS AMC enrolled countries with established surveillance sources (n=8) as denominator.

2.1.2.1 Coordination, structure, data availability and use

The overall results are shown in Table 2 4. National surveillance systems are at different implementation stages, with nine out of 15 countries reporting a national AMC surveillance system under development. The nomination of the leading body is often the first step in establishing a surveillance system and this has been accomplished by 13 countries, while six countries reported a fully established AMC team. A functional surveillance system has defined objectives (structure) that guide the choice of target antimicrobials and data source(s) to capture the most accurate, granular and representative data possible. More than half of the countries have surveillance objectives set, antimicrobials under surveillance specified, and source(s) of AMC data identified. Six countries have all three elements fully defined. In addition to the mandatory group of antimicrobials for systemic use, countries also targeted antifungals (n=5), antimycobacterials to treat TB (n=5) and antimalarial medicines (n=4). Six of the 15 countries reported having an electronic system either automatized (n=1) or semi-automatized (n=5) to manage national AMC data. Data collection is performed routinely in four countries, but only two routinely analyse and disseminate the data.

Table 2.4. Status of implementation of the coordination, structure, data availability and use components of national AMC surveillance systems of countries, territories and areas enrolled in GLASS-AMC as of December 2020 and reporting on implementation in 2020

WHO REGIONS			AFRO	AMR/PAHO	EMRO	SEARO	GLOBAL
			N (%)				
COUNTRIES ENROLLED IN GLASS-AMC PROVIDING INFORMATION ON THE NATIONAL AMC SURVEILLANCE SYSTEM			6	1	3	5	15
COORDINATION	Establishment of a national system to monitor AMC	Fully established	3 (50)	0 (0)	1 (33.3)	0 (0)	4 (26.7)
		Establishment in process	1 (16.7)	1 (100)	2 (66.7)	5 (100)	9 (60)
		Not established	2 (33.3)	0 (0)	0 (0)	0 (0)	2 (13.3)
	Nomination of a government agency/unit to lead the national system	Officially nominated	6 (100)	1 (100)	2 (66.7)	4 (80)	13 (86.7)
		Nomination in progress	0 (0)	0 (0)	0 (0)	1 (20)	1 (6.7)
		Not nominated	0 (0)	0 (0)	1 (33.3)	0 (0)	1 (6.7)
	National team to conduct AMC surveillance activities	Fully established	3 (50)	0 (0)	2 (66.7)	1 (20)	6 (40)
		Establishment In process	2 (33.3)	1 (100)	1 (33.3)	1 (20)	5 (33.3)
		Not established	1 (16.7)	0 (0)	0 (0)	3 (60)	4 (26.7)
STRUCTURE	Definition of surveillance objectives	Defined	4 (66.7)	1 (100)	3 (100)	0 (0)	8 (53.3)
		In progress	0 (0)	0 (0)	0 (0)	5 (100)	5 (33.3)
		Not defined	2 (33.3)	0 (0)	0 (0)	0 (0)	2 (13.3)
	Definition of the antimicrobial classes to target	Defined	3 (50)	1 (100)	2 (66.7)	2 (40)	8 (53.3)
		Definition in progress	0 (0)	0 (0)	1 (33.3)	3 (60)	4 (26.7)
		Not defined	3 (50)	0 (0)	0 (0)	0 (0)	3 (20)
	Selection of the source(s) for AMC data	Data sources selected	3 (50)	1 (100)	3 (100)	1 (20)	8 (53.3)
		In progress	0 (0)	0 (0)	0 (0)	4 (80)	4 (26.7)
		Not selected	3 (50)	0 (0)	0 (0)	0 (0)	3 (20)
DATA AVAILABILITY AND USE	Establishment of an electronic system to manage AMC data	Yes, automatized	0 (0)	1 (100)	0 (0)	0 (0)	1 (6.7)
		Yes, semi-automatized	1 (16.7)	0 (0)	2 (66.7)	2 (40)	5 (33.3)
		In progress	2 (33.3)	0 (0)	1 (33.3)	1 (20)	4 (26.7)
		No	3 (50)	0 (0)	0 (0)	2 (40)	5 (33.3)
	Collection of data on a routine (annual) base	Yes	2 (33.3)	1 (100)	1 (33.3)	0 (0)	4 (26.7)
		In progress	2 (33.3)	0 (0)	2 (66.7)	5 (0)	9 (60.0)
		No	2 (33.3)	0 (0)	0 (0)	0 (0)	2 (13.3)
	Analysis and publication of AMC data on a routine (annual) base	Yes	2 (33.3)	0 (0)	0 (0)	0 (0)	2 (13.2)
		In process	2 (33.3)	1 (100)	3 (100)	3 (60)	9 (60.0)
		No	2 (33.3)	0 (0)	0 (0)	2 (40)	4 (26.7)

2.1.2.2 Coverage and granularity

An ideal national AMC surveillance system should enable collecting such data disaggregated by level of care (primary, secondary and tertiary) for both the public and private sectors (aggregated as "global sector"), with a sub-national and quarterly geographical and temporal granularity. Countries can collect AMC data from several sources along the value chain of medicines. The closer the data source is to the end-user, the more accurate and granular is the estimate. Sources from distribution and dispensing more probably allow for data disaggregation by health sectors (public and private) and levels (hospital and community). However, surveillance can be implemented modularly, starting with the simplest system possible and progressively scaling up. Among the eight reporting countries, six adopted distribution or sales sources, and four adopted import or production sources (Table 2.5). Half of the countries combined different data sources in order to obtain a more comprehensive coverage. Five countries collect AMC data as total care for the global sector. The remaining three countries capture data from a variety of health care sector/level combinations. Data are available in all countries as annual and national figures. Only one country disaggregated data at the sub-national level (Table 2.5).

Of note, these results are not representative of national AMC surveillance systems globally or regionally. However, this is the first attempt to monitor national AMC surveillance implementation globally and it allowed not only to test the proposed GLASS-AMC tools, but also to set a benchmark to monitor the implementation of national AMC surveillance systems over time among the reporting countries.

Table 2.5. Coverage and granularity of national AMC surveillance systems of countries, territories and areas enrolled in GLASS-AMC by December 2020 and reporting on implementation in 2020

WHO REGIONS			AFRO	AMR/PAHO	EMRO	SEARO	GLOBAL
			N (%)				
COUNTRIES ENROLLED IN GLASS THAT REPORTED ESTABLISHED SOURCE(S) FOR AMC DATA			3	1	3	1	8
COVERAGE AND GRANULARITY	Level of data source adopted (more than one may apply)	Level 1: Import/production	1 (33.3)	0 (0)	2 (66.7)	1 (100)	4 (50)
		Level 2-3: Distribution/sales	3 (100)	1 (100)	2 (66.7)	1 (100)	6 (75)
		Level 4-5: Prescribing/patient use	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		Other level other: Market research companies	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Sector and level of the health system covered by the AMC data collected	Aggregated level of care/global sector	3 (100)	0 (0)	2 (66.7)	0 (0)	5 (62.5)
		Aggregated level of care/public sector	0 (0)	0 (0)	1 (33.3)	0 (0)	1 (12.5)
		Disaggregated hospital and primary level of care/public sector	0 (0)	1 (100)	0 (0)	0 (0)	1 (12.5)
		Hospital level/public and private sector	0 (0)	0 (0)	0 (0)	1 (100)	1 (12.5)
	Geographical coverage	National	3 (100)	1 (100)	3 (100)	0 (0)	7 (87.5)
		Sub-national	0 (0)	0 (0)	0 (0)	1 (100)	1 (12.5)
	Temporal coverage	Annual	3 (100)	1 (100)	1 (33.3)	1 (100)	6 (75)
		Quarterly	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		Not reported	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

2.2 GLASS-AMR

GLASS-AMR holds a data call between May and August every year and collects information on the implementation of the national AMR surveillance systems for the data call year, including AMR rates for the previous calendar year. The submission of these data can be done in a stepwise manner. For example, according to the country's priorities and level of resources, they may start by reporting on implementation only or AMR rates for a single indicator and then progressively build capacity to achieve data completeness *(21)*. Information is collected through an annual standardized questionnaire addressing three topics: overall coordination of the system; structure of the system; and the EQA of its diagnostic output. A set of indicators is then used to measure the development and strengthening of national AMR surveillance (Annex 4).

AMR data at national level are collected through a system that gathers results from AST for common human bacterial pathogens on four specimens sent routinely to laboratories for clinical purposes. The "population under surveillance" is defined as patients seeking care in health care facilities. Based on the rationale that the growth of a pathogen in selected specimens is a proxy of infection in the associated anatomical sites, AMR data are collected for four infection sites: BSIs caused by *Acinetobacter* spp., *E. coli*, *K. pneumoniae*, *Salmonella* spp., *S. aureus* and *S. pneumoniae*; UTI caused by *E. coli* and *K. pneumoniae*; gastrointestinal infections caused by *Salmonella* spp. and *Shigella* spp.; and genital infections caused by *N. gonorrhoeae*. Together with patients' microbiological results (bacterial isolation and identification, AST), countries are also invited to report demographic and epidemiological variables in aggregated format, such as age, gender, and origin of infection, with the latter used as a proxy to define where the infection has been contracted (hospital versus community[4]). For all samples taken for microbiological testing, GLASS also collects data on both the number of patients with positive samples for a specific specimen type (including both isolates of the target pathogens and other bacteria, as well as antibiotic susceptibility of positive isolates) and the number of patients with negative samples (no microbial growth) *(18)*.

The GLASS routine surveillance approach is based on the following four main assumptions.

1. That **patients with a specific syndrome will seek care** at a health care facility with access to a diagnostic microbiology laboratory.
2. That **patients with suspected infection have a sample taken according to best clinical practices;** the sample will then be transported to the laboratory for routine microbiology investigations using culture and AST.
3. That **the growth of a pathogen in selected specimens is a proxy of patient infection** in the associated anatomical sites (BSI, UTI, gastrointestinal infection, genital infection). For this to be true, submitted microbiological data must relate to a single episode of illness in a patient. Only the first positive culture for a specific pathogen from the patient for each disease episode is reported for surveillance purposes (deduplication), even if several positive cultures for that pathogen are obtained or resistance emerges in the same pathogen during treatment.
4. That the number of isolates with laboratory AST results can be used as a **representation of the number of patients infected** with targeted susceptible or resistant bacteria in a specific anatomical site after deduplication.

Annex 5 describes in more detail these assumptions and related important limitations, including existing practical constraints of routine approaches and their shortcomings. Understanding the sources and directions of bias generated is essential to interpreting generated data and to address the need for implementation of additional surveillance approaches

A readers' guide to the results and analytical limitations of GLASS-AMR is available in Annex 4. Considerations regarding AMR surveillance approaches are listed in Annex 5.

2.2.1 Participation and reporting

By the end of the fourth data call on 31 August 2020, 94 countries, territories and areas were enrolled in GLASS-AMR. These 94 countries include a mix of countries in various stages of economic development from across all WHO regions (14 LICs, 28 LMICs, 17 UMICs, and 35 HICs) *(36)* (Table 2.6). Among these, 82 countries, territories and areas submitted data in 2019 (Fig. 2.2): 12 countries provided only information on the status of their national AMR surveillance systems; four countries provided AMR rates only; and 66 countries provided both information on the status of their national AMR surveillance systems and 2019 AMR rates.

Both AST results and the number of patients from whom a sample was taken were provided in aggregated form by 25 (36%) of the 70 countries, territories and areas. Four countries that submitted only information on the status of their national AMR surveillance system in the previous call also reported 2019 AMR rates. However, four countries that reported AMR rates in 2019 were unable to report in 2020.

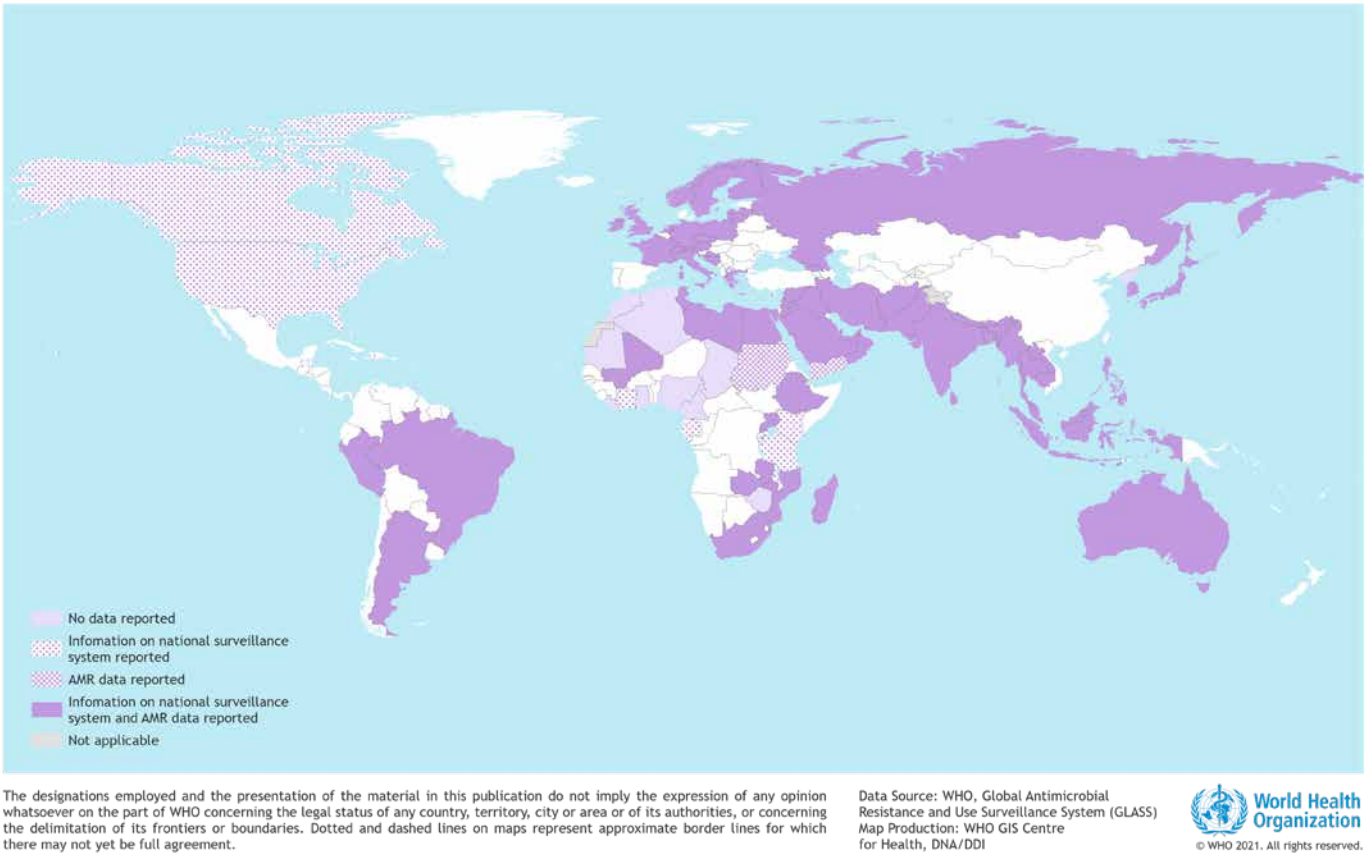
4 Infection origin: hospital, community, unknown. Countries were advised to use the following definition: 'Hospital' origin is selected for patients admitted for >2 calendar days when the specimen was taken or admitted to the health care facility for ≤2 calendar days, but transferred from another health care facility where he/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. Countries using a different classification method were nevertheless invited to report infection origin data in the GLASS format.

Table 2.6. Information reported by countries, territories and areas enrolled in GLASS on 31 August 2020

GLASS REPORT 2021	INCOME LEVEL[a]			
	LOW	LOW-MIDDLE	UPPER-MIDDLE	HIGH
No data reported (n=12)	Chad	Algeria	Maldives	
	Democratic People's Republic of Korea	Cameroon		
	Liberia	Djibouti		
		Ghana		
		Mauritania		
		Morocco		
		Nigeria		
		Zimbabwe		
Information on implementation only (n=12)	Burundi	Côte d'Ivoire	Gabon	Canada
	Gambia	Kenya		Mauritius
	Malawi	Timor-Leste		Trinidad and Tobago
		United Republic of Tanzania		United States of America
AMR data only (n=4)	Sudan		North Macedonia	Cyprus
	Yemen			
AMR data and information on implementation (n=66)	Afghanistan	Bangladesh	Bosnia and Herzegovina	Argentina
	Ethiopia	Bhutan	Brazil	Australia
	Madagascar	Cambodia	Georgia	Austria
	Mali	Egypt	Indonesia	Bahrain
	Syrian Arab Republic	India	Iran (Islamic Republic)	Brunei Darussalam
	Uganda	Jordan	Iraq	Croatia
		Lao People's Democratic Republic	Lebanon	Czechia
		Mozambique	Libya	Finland
		Myanmar	Malaysia	France
		Nepal	Peru	Germany
		Occupied Palestinian territories and East Jerusalem	South Africa	Greece
		Pakistan	Thailand	Ireland
		Philippines	Russian Federation	Italy
		Sri Lanka		Japan
		Tunisia		Latvia
		Zambia		Lithuania
				Luxembourg
				Malta
				Netherlands
				Norway
				Oman
				Poland
				Qatar
				Republic of Korea
				Saudi Arabia
				Singapore
				Sweden
				Switzerland
				United Arab Emirates
			Kosovo[b]	United Kingdom of Great Britain and Northern Ireland

a World Bank Country and Lending Groups (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).
b All references to Kosovo in this document should be understood in the context of the UN Security Council resolution 1244 (1999).

Fig. 2.2. GLASS AMR data submission by the end of the 2020 data call on 31 August 2020



Overall, 1907 hospitals, 19 721 outpatient clinics, and 2860 hospitals with outpatient facilities reported data on AMR to GLASS. GLASS also received data from 315 laboratories in countries that cannot yet obtain information from the surveillance sites where the samples were taken. EQA of bacterial identification and AST in laboratories reporting to GLASS varied by region. A summary of EQA in NRL and local laboratories participating in national surveillance systems is given in Section 2.2.2.3.

In total, 68 countries submitted results for BSI, 47 UTI, 37 for gastrointestinal infections, and 27 for gonorrhoea. The most frequently reported pathogens were in descending order: *E. coli* and *Acinetobacter* spp. (97%), *K. pneumoniae* (94%), *S. aureus* (91%), *S. pneumoniae* (73%), *Salmonella* spp. (64%), *Shigella* spp. (53%), and *N. gonorrhoeae* (39%) (Annex 6).

The number of patients with suspected infection from whom a pathogen was isolated varied considerably and ranged from a minimum of 28 to a maximum of 822 931 patients per country. Countries reported information for a combined total of 3 124 982 laboratory-confirmed infections caused by pathogens under surveillance (Table 2 7). As shown in the boxplot in Section 2.2.3, AST varied widely regarding both the choice of isolates tested and the drugs considered among countries and in the specimen-pathogen-antibiotic combinations tested.

Table 2.7. Numbers of reported infections and AST results for pathogens under surveillance

INFECTION SITE	TOTAL NUMBER OF INFECTIONS CAUSED BY PATHOGENS UNDER SURVEILLANCE	PATHOGEN	NUMBER OF INFECTED PATIENTS (BY PATHOGEN)				TOTAL NUMBER OF AST RESULTS FOR PATHOGENS UNDER SURVEILLANCE	PATHOGEN	NUMBER OF PATIENTS WITH AST RESULTS (BY PATHOGEN)[a]			
			COMMUNITY	HOSPITAL	UNKNOWN	TOTAL			COMMUNITY	HOSPITAL	UNKNOWN	TOTAL
Bloodstream	**520 154**	*Acinetobacter* spp.	2 666	5 074	15 931	**23 671**	**502 980**	*Acinetobacter spp.*	2 348	4 820	14 894	**22 062**
		E. coli	61 580	39 919	153 454	**254 953**		*E. coli*	61 080	39 681	151 504	**252 265**
		K. pneumoniae	19 268	18 968	54 108	**92 344**		*K. pneumoniae*	19 008	18 591	52 099	**89 698**
		Salmonella spp.	1 930	666	10 820	**13 416**		*Salmonella spp.*	1 839	631	9 901	**12 371**
		S. aureus	19 966	23 105	72 551	**115 622**		*S. aureus*	18 154	22 322	66 610	**107 086**
		S. pneumoniae	3 725	1 340	15 083	**20 148**		*S. pneumoniae*	3 480	1 294	14 724	**19 498**
Urinary tract	**2 577 936**	*E. coli*	491 789	178 666	1 596 011	**2 266 466**	**2 503 241**	*E. coli*	459 221	177 365	1 564 803	**2 201 389**
		K. pneumoniae	81 332	47 395	182 743	**311 470**		*K. pneumoniae*	77 198	46 879	177 775	**301 852**
Gastrointes-tinal	**17 210**	*Salmonella spp.*	4 206	367	8 201	**12 774**	**14 747**	*Salmonella spp.*	3 460	302	6 665	**10 427**
		Shigella spp.	427	28	3 981	**4 436**		*Shigella spp.*	420	28	3 872	**4 320**
Genital	**9 682**	*N. gonorrhoeae*	8 576	5	1 101	**9 682**	**9 445**	*N. gonorrhoeae*	8 383	4	1 058	**9 445**
Total	**3 124 982**						**3 030 413**					

a For one or more antibiotics required by GLASS reporting.

2.2.2 Implementation status of national AMR surveillance systems

The total number of countries per WHO region and the number of countries reporting to GLASS in the fourth data call in 2020 are shown in Table 2.8. As described in Annex 4, the indicators are summarized as country proportions and listed by region for the three areas of implementation, that is, coordination, surveillance systems, and quality assurance and standards. Proportions are calculated with the total number of countries, areas and territories in each region as the denominator. The yearly variation of results can be related to changes in the development of the national surveillance systems, but also to changes in countries reporting behaviour. For example, five countries that submitted the implementation questionnaire for the 2019 data call, did not report this data in 2020 due to constraints linked to the coronavirus disease 2019 (COVID-19) pandemic. For this reason, the interpretation of trends should be carefully considered.

Table 2.8. WHO Member States, territories and areas per region enrolled in GLASS that reported information on their national surveillance systems in the third data call

REGION	NO. OF COUNTRIES, TERRITORIES AND AREAS	NO. OF COUNTRIES, TERRITORIES AND AREAS ENROLLED IN GLASS[a]	NO. OF COUNTRIES, TERRITORIES AND AREAS THAT REPORTED INFORMATION FROM THE NATIONAL SURVEILLANCE SYSTEM TO GLASS
African	47	23	15
Americas/PAHO	35	6	6
Eastern Mediterranean	22	20	16
European[b]	54	25	23
South-East Asia	11	11	9
Western Pacific	27	9	9
Total	**196**	**94**	**78**

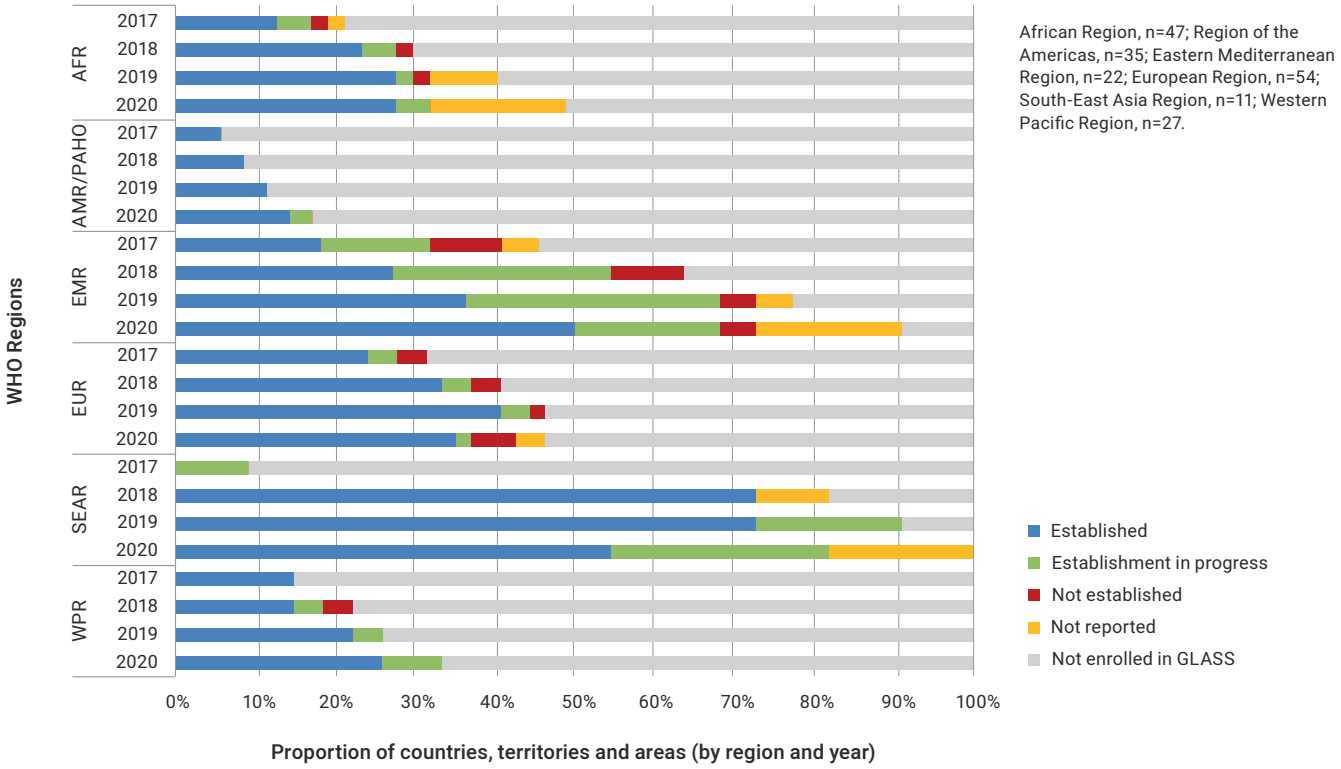
a At the end of the 2020 data call, that is, 31 August 2020.

b Kosovo included: all references to Kosovo in this document should be understood in the context of UN Security Council resolution 1244 (1999).

2.2.2.1 Coordination

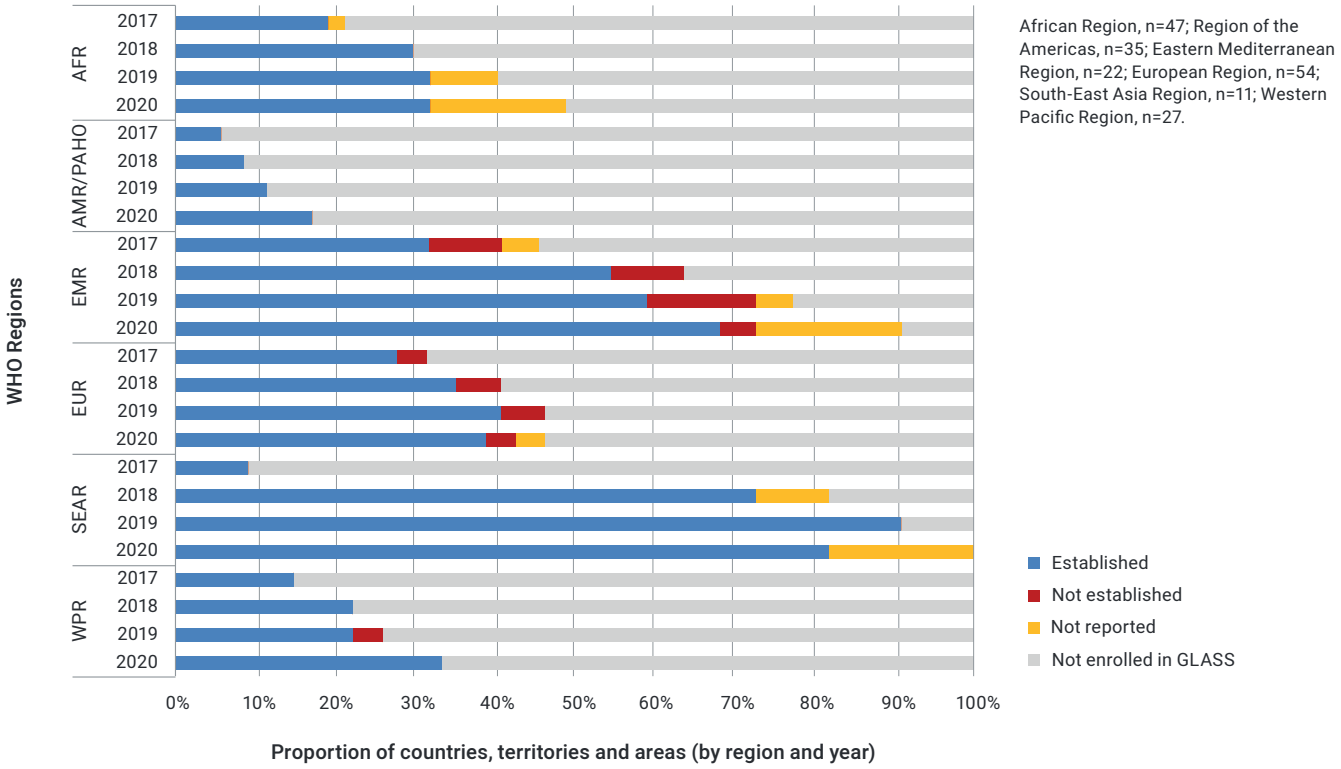
Most of the core components for effective surveillance suggested by GLASS are present in the majority of countries in all regions, that is, defined surveillance sites, the national coordinating centre, and the NRL to support national AMR surveillance (Fig. 2.3-4). GLASS has enrolled countries with both established core components for AMR national surveillance and those that are still establishing these elements, with a marked evolution of functional national coordinating centres. NRLs are usually already nominated by countries. These core components secure the correct flow of information to national bodies and GLASS and are essential in data preparation and submission, as well as for the coordination and quality of the data generated.

Fig. 2.3. Establishment of national coordinating centres in GLASS enrolled countries, territories and areas by region and year



African Region, n=47; Region of the Americas, n=35; Eastern Mediterranean Region, n=22; European Region, n=54; South-East Asia Region, n=11; Western Pacific Region, n=27.

Fig. 2.4. Establishment of NRLs in GLASS enrolled countries, territories and areas by region and year



African Region, n=47; Region of the Americas, n=35; Eastern Mediterranean Region, n=22; European Region, n=54; South-East Asia Region, n=11; Western Pacific Region, n=27.

2.2.2.2 Surveillance systems

The national surveillance system structure is monitored according to the number of surveillance sites and local laboratories that perform AST and report AMR data to GLASS (Table 2.9), which are the main data sources in all regions. The surveillance coverage and representativeness vary considerably due to factors such as the size and geographical features of the country, the structure of the national health care system, the characteristics of the sites, and logistic and economic constraints. The number also depends on the structure of the surveillance that was previously in place, especially if it was based on laboratory reporting only. Although the number of surveillance sites may vary, coverage and representativeness are expected to improve as surveillance systems mature. Most patient data are derived from hospital surveillance sites compared to outpatient care, but it is paramount for countries to also monitor AMR in the community. In addition, the involvement of private hospitals is crucial to generate more representative AMR surveillance data.

Table 2.9. Numbers of surveillance sites reporting to GLASS by region and year. Number of countries reporting AMR data: 2017=22; 2018=49; 2019=66; 2020=70. The annual variation of the number of sites reporting can be related to changes in countries' AMR data submission behaviour, which was highly impacted in 2020 by the COVID-19 pandemic

REGION	SURVEILLANCE SITES	2017	2018	2019	2020
African	Hospitals	30	30	39	217
	Outpatient facilities	5	5	42	9
	In- and outpatient facilities				11
	Laboratories[a]		5	12	14
	Total	**35**	**40**	**93**	**251**
Americas	Hospitals			4132	76
	Outpatient facilities			40 600	6
	In- and outpatient facilities				76
	Laboratories[a]				
	Total	**0**	**0**	**44 732**	**158**
Eastern Mediterranean	Hospitals	54	100	168	149
	Outpatient facilities	109	129	204	59
	In- and outpatient facilities				303
	Laboratories[a]		6	1	16
	Total	**163**	**235**	**373**	**527**
European	Hospitals	131	947	1117	1232
	Outpatients facilities	6	145	15 901	19 558
	In- and outpatient facilities				308
	Laboratories[a]	147	412	363	259
	Total	**284**	**1504**	**17 381**	**21 357**
South-East Asian	Hospitals	2	28	34	129
	Outpatient facilities		1	3	5
	In- and outpatient facilities		13	25	87
	Laboratories[a]		15	48	26
	Total	**2**	**57**	**110**	**247**
Western Pacific	Hospitals	6	58	67	104
	Outpatient facilities		68	68	2
	In- and outpatient facilities	22	2026	1973	2075
	Laboratories[a]				
	Total	**28**	**2152**	**2108**	**2181**

a The number of surveillance sites that submit specimens to participating laboratories could not be identified because of the structure of the national surveillance system. The number of laboratories supporting the surveillance system are reported instead.

2.2.2.3 Quality assurance and strandards

The EQA component of implementation comprises three indicators: number of assessments in the NRLs and local laboratories; international standards used. In 80% of reporting countries, the NRLs participate in an EQA scheme (Fig. 2.5), and in 99% of countries reporting GLASS, laboratories perform AST according to internationally recognized standards, that is, those of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) or the Clinical and Laboratory Standards Institute (Fig. 2.6) *(37, 38)*. However, EQA is still not performed in all clinical laboratories that serve national AMR surveillance programmes (Fig. 2.7) and this is an issue as quality management is crucial to ensure that test results are interpretable.

Fig. 2.5. Provision of EQA to NRLs in GLASS enrolled countries, territories and areas by region and year

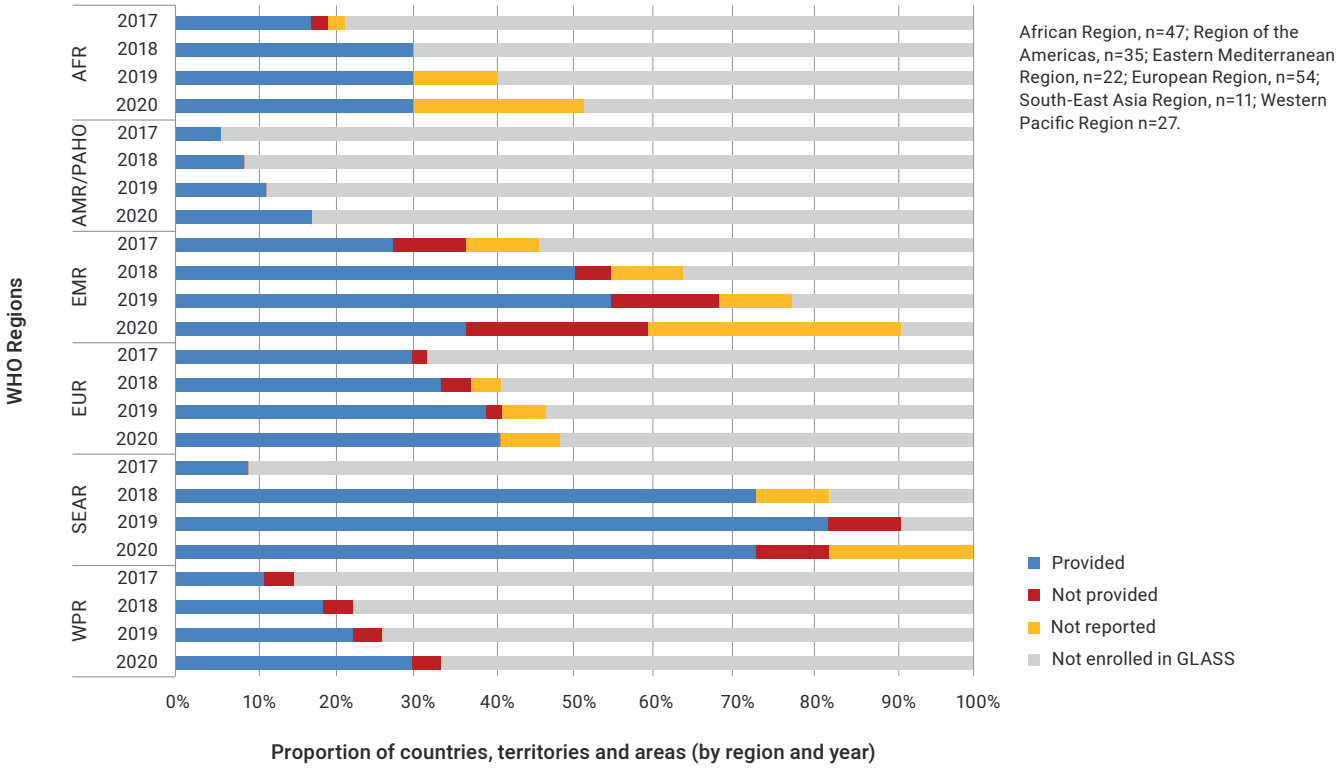
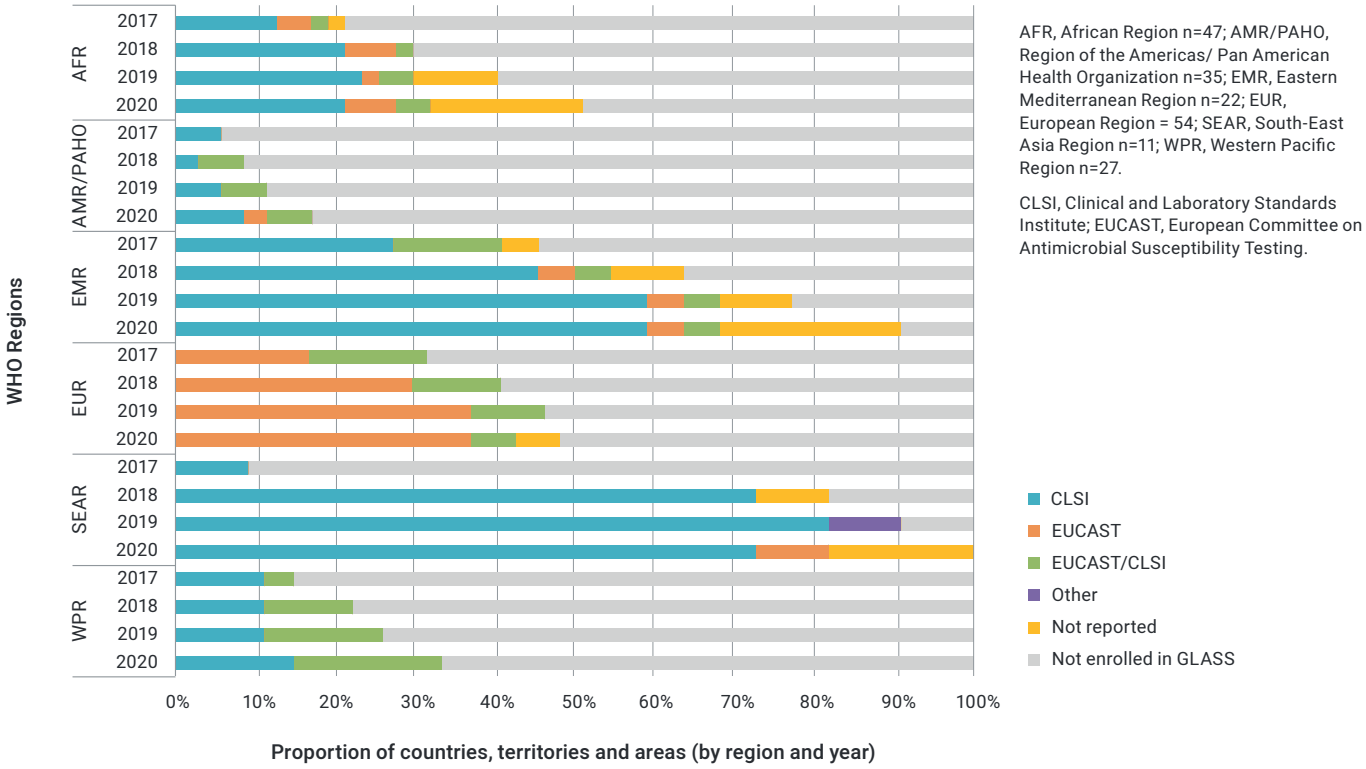


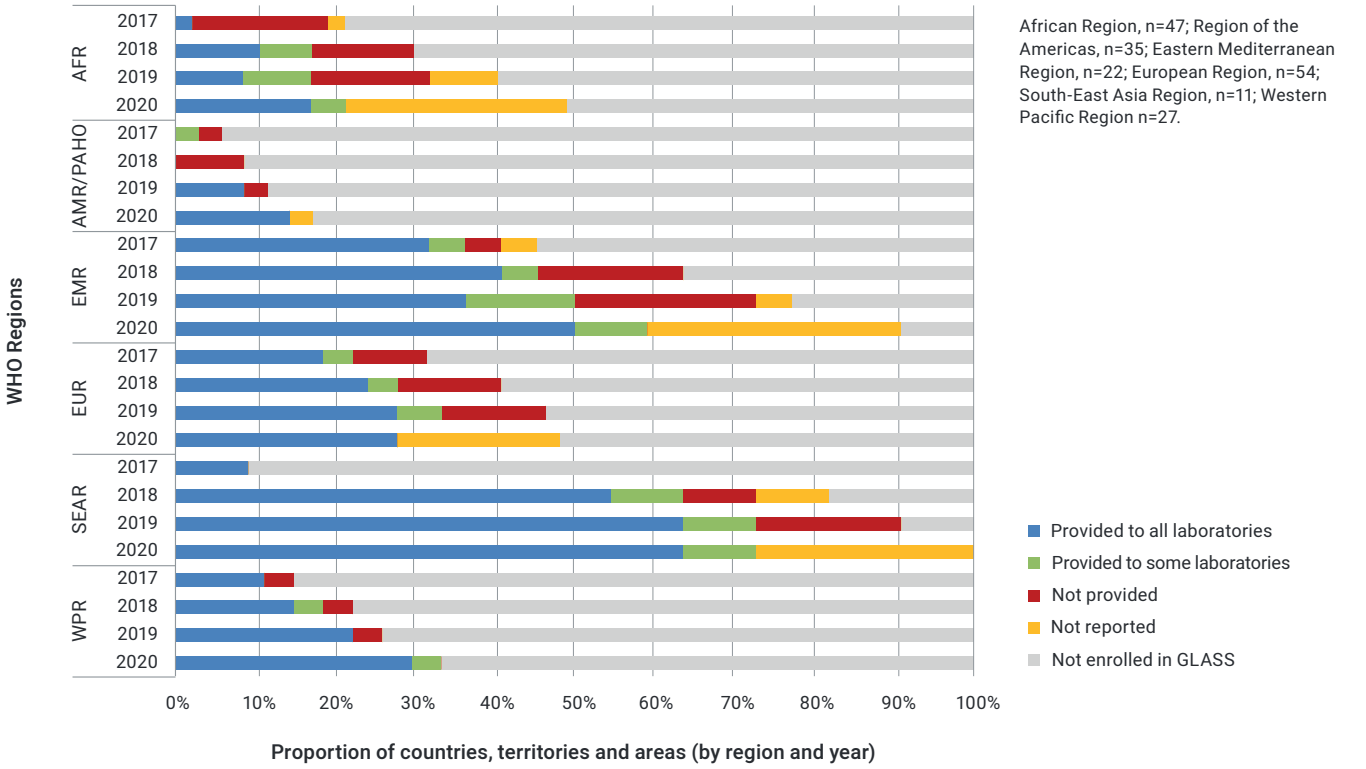
Fig. 2.6. International standards for AST used in GLASS enrolled countries, territories and areas by region and year



AFR, African Region n=47; AMR/PAHO, Region of the Americas/ Pan American Health Organization n=35; EMR, Eastern Mediterranean Region n=22; EUR, European Region = 54; SEAR, South-East Asia Region n=11; WPR, Western Pacific Region n=27.

CLSI, Clinical and Laboratory Standards Institute; EUCAST, European Committee on Antimicrobial Susceptibility Testing.

Fig. 2.7. Provision of EQA to local laboratories that perform AST in GLASS enrolled countries, territories and areas by region and year



African Region, n=47; Region of the Americas, n=35; Eastern Mediterranean Region, n=22; European Region, n=54; South-East Asia Region, n=11; Western Pacific Region n=27.

2.2.3 Global summary of reported AMR data

Global summaries of the proportions of patients with resistant infections per combination of specimen, pathogen and antibiotic are presented in Section 2.2.3. Of note, the summaries should be interpreted carefully due to data limitations described in Annex 5. In general, a large variability is observed in reported results and should be expected when considering the large differences in the number of tested patients reported by countries for each specimen-pathogen-antibiotic combination, together with general data limitations previously described. However, this variability is a key information in itself as it may allow a better understanding of differences in countries AST and reporting behaviour, and thus to more effectively address information gaps in the future.

At the beginning of 2019, EUCAST changed the definitions of the 'S', 'I' and 'R' susceptibility testing categories where 'I' is now defined as 'susceptible, increased exposure', while the Clinical and Laboratory Standards Institute maintains the 'intermediate' category. With the introduction of the new category definitions, GLASS does not merge categories (neither S+I nor I+R) any longer when reporting surveillance data and presents S, I and R separately (Annex 7). Box-and-whisker plots are used to summarize the proportions of patients with resistant and non-susceptible AST results for specific specimen-pathogen-antibiotic combinations, showing the distribution of values along an axis. The boxes indicate the middle 50% of data (that is, the middle two quartiles[5] of the data distribution). The "whiskers" display all points within 1.5 times the interquartile range (IQR), that is, all points within 1.5 times the width of the adjoining box. Each red dot represents a country's reported AMR rate. Note that countries may not report or test for all the pathogen-antibiotic combinations listed by GLASS. The number of countries for which results are reported and the number of patients with isolates screened for resistance are shown below the x-axis after application of cut-off values. Rates are shown only if results were reported for >10 patients and for pathogen-antibiotic combinations with >10 AST results. The list of pathogen-antibiotic combinations countries can report to GLASS is available in Annex 8.

2.2.3.1 Bloodstream infections

BSIs have high morbidity worldwide and an estimated overall crude mortality rate of 15-30% *(39)*. GLASS collects data on six pathogens causing BSIs, four Gram-negatives (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Salmonella* spp.) and two Gram-positives (*S. aureus* and *S. pneumoniae*).

2.2.3.1.1 SDG AMR indicators

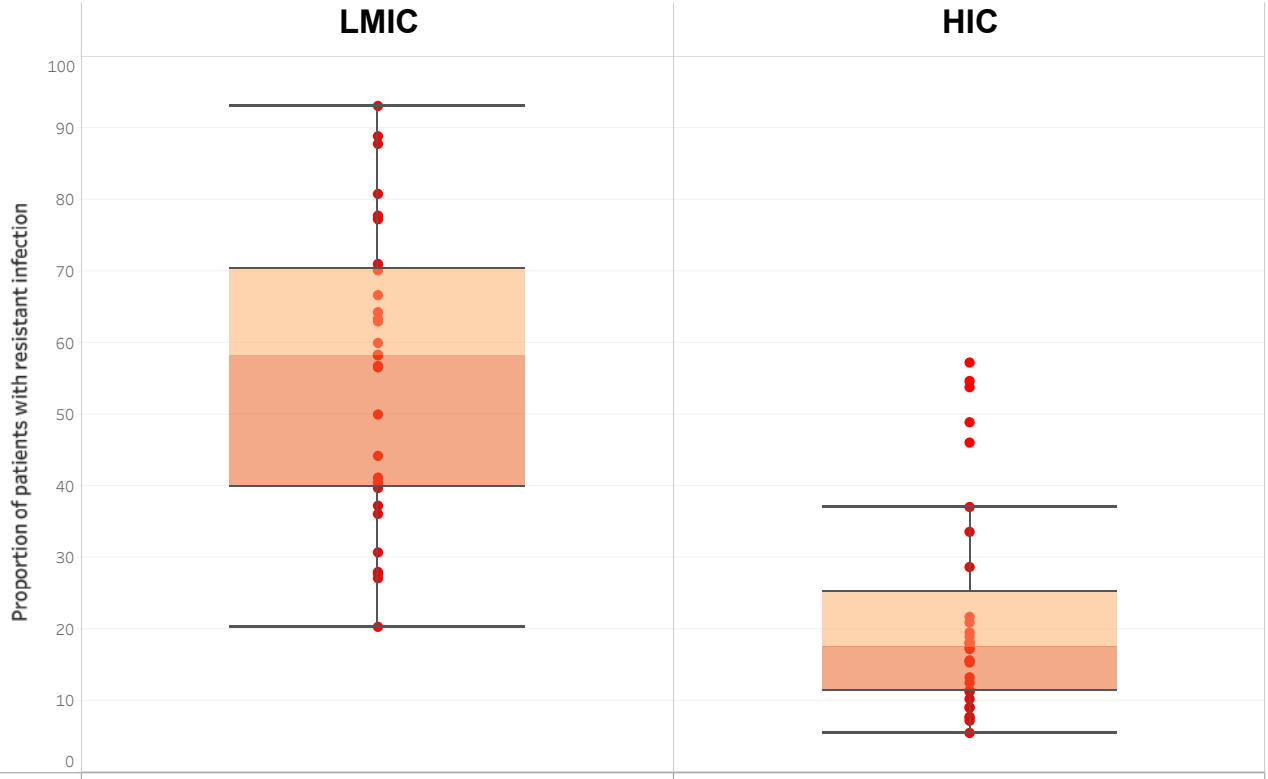
In 2020, two new AMR indicators were included in the monitoring framework of the SDGs linked to the health target 3.d ("strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks"). These indicators monitor the proportion of BSIs due to *E. coli* resistant to 3rd generation cephalosporins and MRSA *(6)*.

E. coli is the most common pathogen causing BSI worldwide and the data in this report confirm the published literature *(40)*. With regard to BSIs due to *E. coli* resistant to 3rd generation cephalosporins (Fig. 2.12), the median proportion of patients with *E. coli* isolates resistant to ceftazidime was found to be lower than those resistant to cefotaxime and ceftriaxone. This could indicate a predominance of ESBL-type cefotaximases in some countries that should be confirmed and characterized with the use of molecular tests as this resistance mechanism has a potential for horizontal transmission and to be associated with cross-resistance to other antibiotic families such as fluoroquinolones *(41)*, which is of relevance as both antibiotic classes belong to the AWaRE "Watch" list.

An important difference in rates of *E. coli* resistance to 3rd generation cephalosporins has been observed between LMICs (58.3%; IQR 39.8-70.2) and HICs (17.53%; IQR 11.3-25.2). The higher rates in LMICs need to be further investigated to assess the impact of potential biases, considering also the very large discrepancy in the numbers of tested patients. Although the number of reporting countries is very similar (32 versus 31), the differences in the numbers of tested patients (22 371 versus 218 031, respectively) might have an impact of reported rates and show how testing coverage for BSIs widely varies according to the income level.

5 The interquartile range (IQR) is a measure of variability, based on dividing a data set into quartiles. Quartiles divide a rank-ordered data set into four equal parts. The IQR is the difference between the first and third quartiles. The first quartile, denoted Q1, is the value in the data set that holds 25% of the values below the median. The third quartile, denoted Q3, is the value in the data set that holds 25% of the values above the median.

Fig. 2.8. Proportion of patients with BSIs caused by *E. coli* resistant to 3rd generation cephalosporins by country income level



	LMIC	HIC
Reporting countries *(n)*	32	2
Patients with AST results *(n)*	22 371	218 031

LMIC, low-middle income countries; HIC, high-income countries

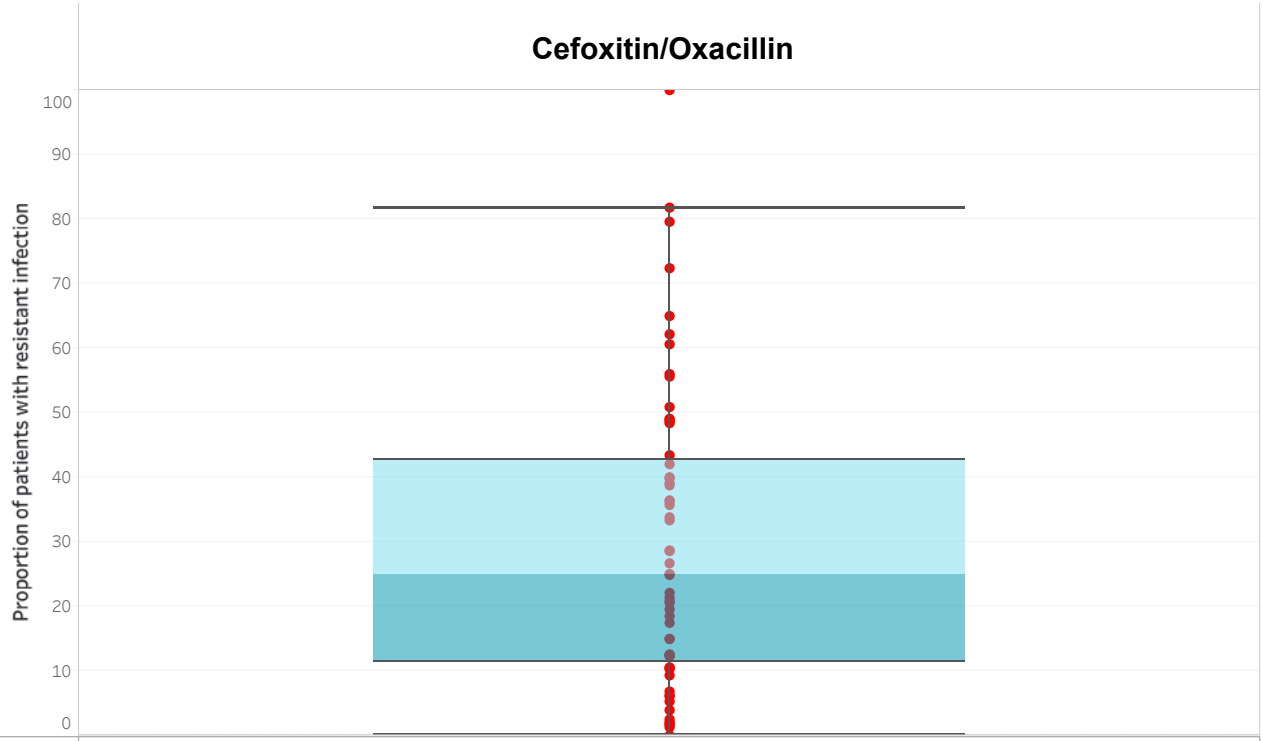
The second SDG AMR indicator is MRSA. *S. aureus* can cause skin, soft tissue, and BSI in humans and is known to be frequently antibiotic-resistant. Indeed, MRSA infections continue to be a major public health concern, accounting for a significant number of health care-associated infections and an increasing incidence of community-acquired infections *(42)*.

Eighty-seven percent of countries *(59)* submitting AMR data to GLASS reported an AST result, for either cefoxitin or oxacillin in *S. aureus* isolates causing BSIs (Fig. 2.9). Although the Clinical and Laboratory Standards Institute and EUCAST recommend the use of cefoxitin instead of oxacillin when using the disk diffusion method to determine resistance against methicillin for *S. aureus*, few (n=10) countries reported only susceptibility to oxacillin *(37, 38)*.

Comparisons of rates in HICs versus LMICs also suggest higher rates in LMICs. The reported median rates of 33.3% (IQR 19.5-55.6) in LMICs and 15% (IQR 6.8-36) in HICs (Fig. 2.10) among a total of 106 868 patients tested suggest that careful consideration should be given to the spread of this resistance pattern, and consistent monitoring should be put in place in every country. This is particularly concerning as MRSA has been associated with significant morbidity and mortality and poses a visible threat in many LMICs where there may be a relatively limited availability of modern antibiotics effective against MRSA *(43)*.

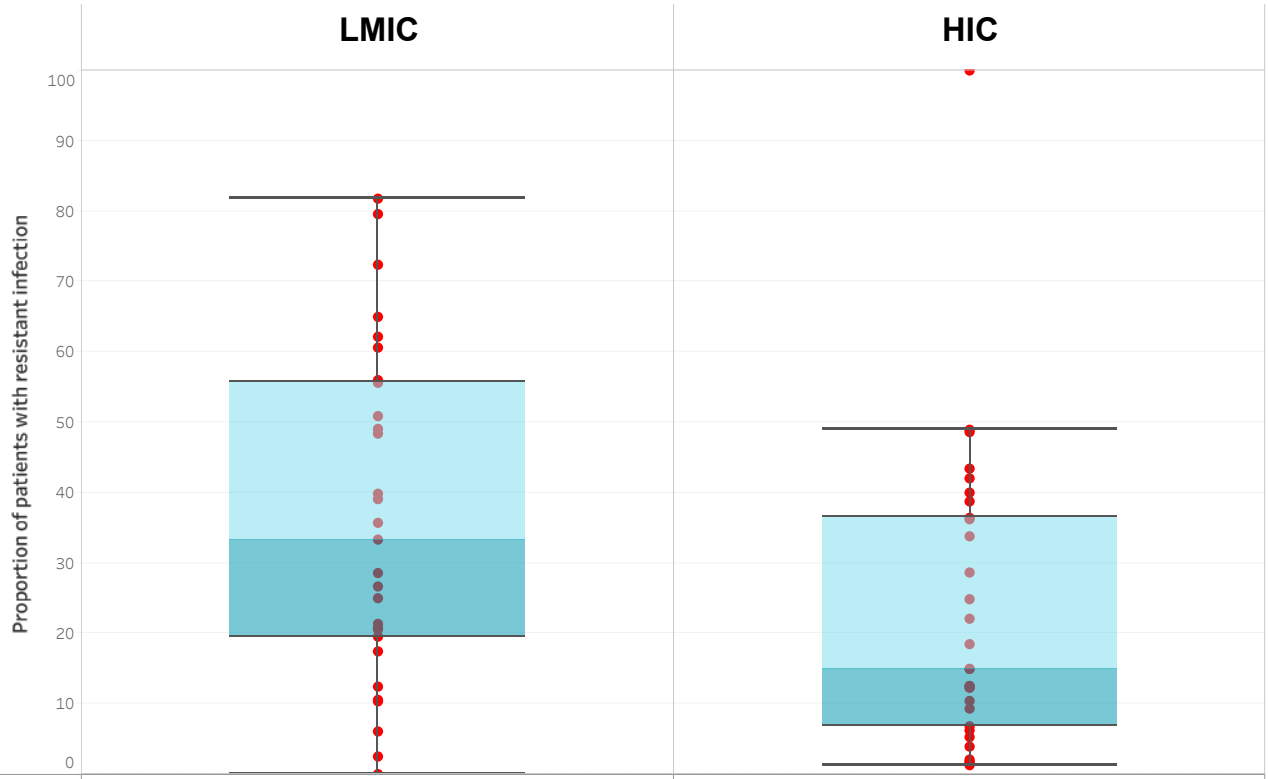
Interestingly, although the number of countries reporting on these two indicators only slightly varied, the number of reported BSIs (218 031) caused by *E. coli* in HICs is much higher than the number of BSIs due to *S. aureus* (83 837). For both indicators, the number of tested patients remains lower in LMICs, while the rate of reported resistance is higher. To be able to interpret these results, targeted studies are needed to better understand clinical practices in different settings and how the income level or other factors might impact on appropriate infection prevention and control practices and diagnostic stewardship.

Fig. 2.9. Proportion of patients with BSIs caused by resistant *S. aureus*



Reporting countries *(n)*	59
Patients with AST results *(n)*	106 858

Fig. 2.10. Proportion of patients with BSIs caused by MRSA by country income level



	LMIC	HIC
Reporting countries *(n)*	29	30
Patients with AST results *(n)*	23 031	83 837

LMIC, low-middle income countries; HIC, high-income countries

2.2.3.1.2 BSIs due to other types of AMR

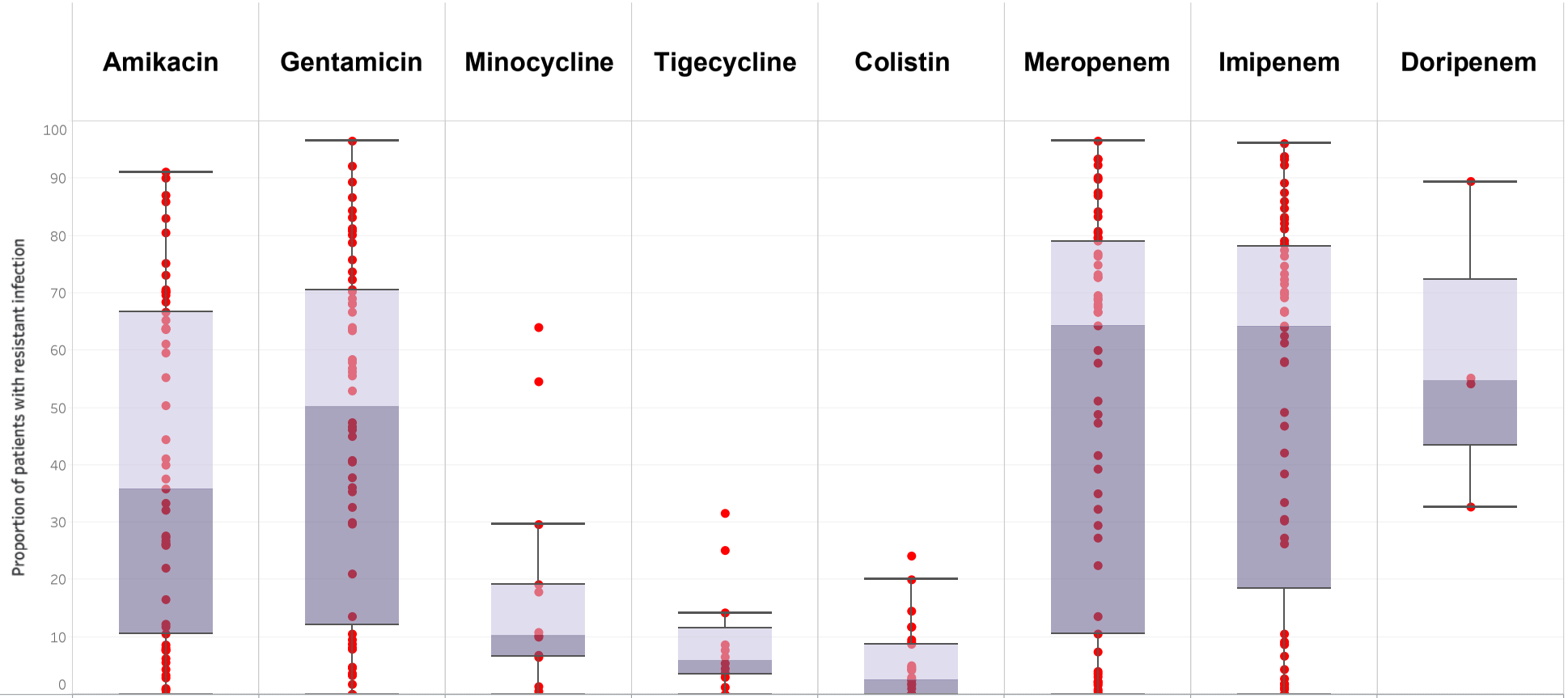
Acinetobacter spp. has become a frequent pathogen in hospitals and other health care settings *(44)*. One of the most important factors contributing to the high mortality of patients with health care-associated infections caused by *Acinetobacter* spp. is its ability to acquire a wide variety of antibiotic resistance genes and rapid develop into multidrug-resistant (MDR), extensively drug-resistant (XDR), and even pan-drug-resistant (PDR) strains. For example, the emergence and spread of drug-resistant *A. baumannii* strains has significantly limited the choice of available therapeutic options and is associated with a worse clinical outcome *(45)*.

GLASS reports *Acinetobacter* spp. as a proxy for *A. baumannii* due to the technical challenges' countries may encounter to identify *Acinetobacter* spp. at the species level, particularly for the *A. baumannii* group. The most frequent *Acinetobacter* species recovered in clinical samples are those included in the A. baumannii group, which includes *A. baumannii, A. nosocomialis, A. pittii, A. dijkshoorniae* and *A. seifertii (46)*. The accurate identification of *A. baumannii* is obtained through molecular methods, which are not yet easily available in many countries. Data reported by countries on *Acinetobacter* spp. in BSIs (Fig. 2.11) showed a high resistance to carbapenems, with a median of 64.3% (IQR 10.5-79.1) and 64% (IQR 18.4–78) for imipenem and meropenem, respectively, and 54.7% (IQR 43.4–73.2) for doripenem – all with a wide range of variability. Of note, the number of countries currently reporting doripenem and the number of patients with AST results for this antibiotic is considerably lower than those for meropenem and imipenem and should be interpreted with caution. The use of molecular markers that will be incorporated in GLASS 2.0 would allow to further characterize the underlying carbapenem resistance mechanisms and potential for horizontal transmission between bacteria. Observed resistance to carbapenems is worrisome as these were last resort antibiotics used for managing MDR bacterial infections until recently, thus now leading to extremely limited treatment options for infections caused by carbapenem-resistant *A. baumannii*, with few new drugs under development *(47, 48)*. For these reasons, all three mentioned carbapenems are in the AWaRE "Watch" list and should be used with caution *(31)*.

In this report, *Acinetobacter* spp. with moderate-to-high resistance levels to aminoglycosides were also observed in data reported by countries. Aminoglycosides are widely used to treat hospital-acquired infections caused by Gram-negative bacilli, including *A. baumannii* strains. However, high resistance to traditional aminoglycoside agents such as gentamicin and kanamycin is common among clinical isolates of *A. baumannii*, and increasing resistance to amikacin is being reported in many countries worldwide *(45)*. This is of particular interest as both antibiotics are included in the "Access" group of the AWaRE list and are recommended as essential first- or second-choice empiric treatment options for infectious syndromes reviewed by the Essential Medicines List Expert Committee, and also listed as individual medicines on the Model Lists of Essential Medicines to improve access and promote appropriate use *(31)*.

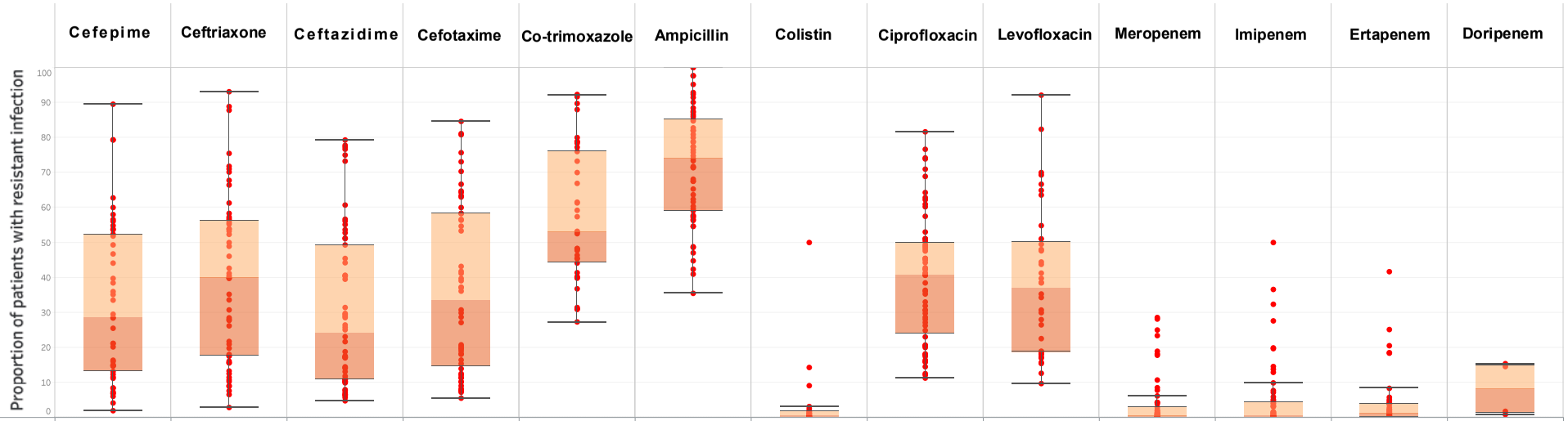
In addition to the importance of *E. coli* resistance to 3rd generation cephalosporins as already discussed in Section 2.2.3.1.1, it is relevant to highlight the high proportion of patients with BSIs due to *E. coli*-resistant ampicillin or co-trimoxazole, both antibiotics belonging to the AWaRE "Access" list *(31)*. Similar to BSIs due to *K. pneumoniae* (Fig. 2.13), the most important finding is the moderate-to-high resistance levels to all 3rd and 4th generation cephalosporins, as well as low-to-moderate resistance levels to all carbapenems ("Watch" antibiotics in the AWaRE list). Considering the increasing global threat that ESBL-producing and carbapenem-resistant Enterobacterales represent, including current challenges associated with treatment of the latter pathogens, the confirmation and characterization of resistant isolates with the use of molecular tests becomes highly relevant *(49, 50)*.

Fig. 2.11. Proportion of patients with BSIs caused by resistant *Acinetobacter* spp



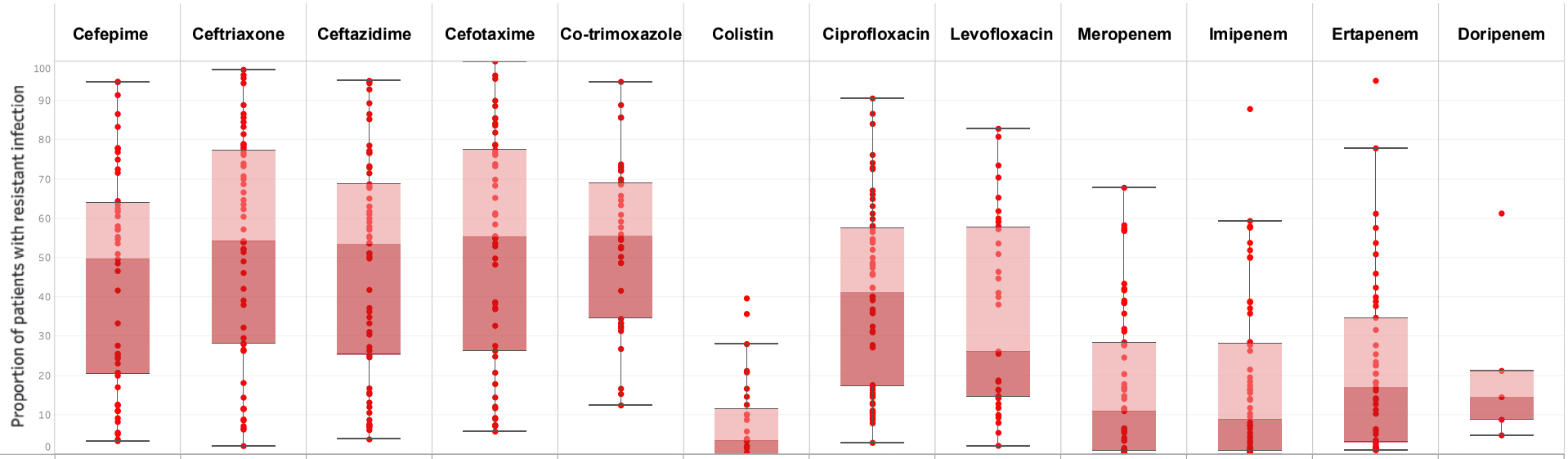
	Amikacin	Gentamicin	Minocycline	Tigecycline	Colistin	Meropenem	Imipenem	Doripenem
Reporting countries *(n)*	53	56	13	12	30	57	55	4
Patients with AST results *(n)*	15 705	15 130	4 756	2 599	4 070	18 340	17 793	312

Fig. 2.12. Proportion of patients with BSIs caused by resistant *E. coli*



	Cefepime	Ceftriaxone	Ceftazidime	Cefotaxime	Co-trimoxazole	Ampicillin	Colistin	Ciprofloxacin	Levofloxacin	Meropenem	Imipenem	Ertapenem	Doripenem
Reporting countries *(n)*	46	55	58	52	37	57	27	63	36	58	60	45	4
Patients with AST results *(n)*	146 061	126 630	235 051	189 801	33 737	194 891	17 931	213 010	120 532	232 270	175 833	98 567	1 712

Fig. 2.13. Proportion of patients with BSIs caused by resistant *K. pneumoniae*



	Cefepime	Ceftriaxone	Ceftazidime	Cefotaxime	Co-trimoxazole	Colistin	Ciprofloxacin	Levofloxacin	Meropenem	Imipenem	Ertapenem	Doripenem
Reporting countries *(n)*	47	56	57	50	38	31	62	35	59	58	45	5
Patients with AST results *(n)*	59 726	45 414	81 448	69 088	23 946	11 202	75 627	39 047	82 783	68 190	38 556	947

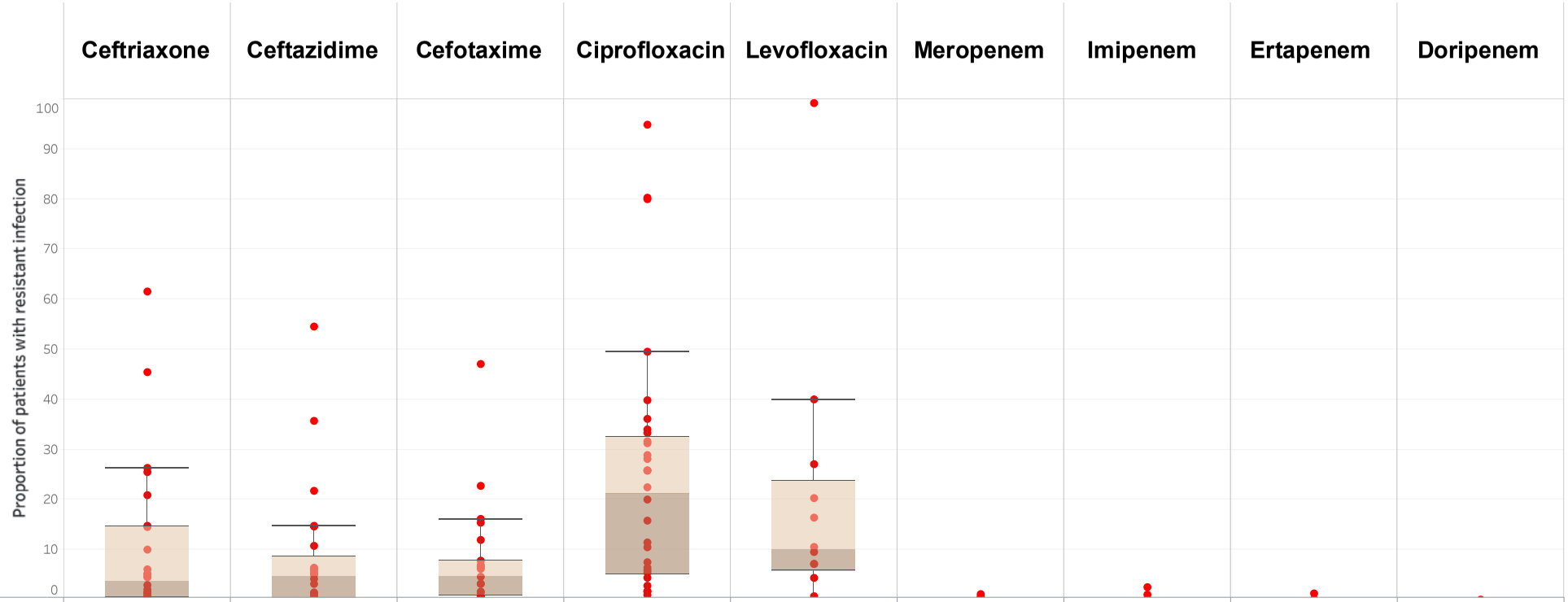
Salmonella spp. mainly cause inflammation of the intestine (gastroenteritis), but sometimes the bacteria enter the bloodstream (causing bacteremia) and spread, causing infections or collections of pus (abscesses) at distant sites, such as the bones, joints, urinary tract, and lungs. Fluoroquinolones are antimicrobials commonly used to treat salmonellosis. Data on ciprofloxacin resistance in *Salmonella* spp. was collected for 32 countries (Fig. 2.14), with a median resistance of 23.3% (IQR 4.9-32.8); levofloxacin median resistance was markedly lower at 10.03% (IQR 5.7 – 23.7). However, since the number of reporting countries and tested patients was also lower, this difference should be interpreted with caution. Another relevant finding is the low resistance levels found for all carbapenems.

S. pneumoniae is the causative agent for a wide variety of life-threatening infections including pneumonia, meningitis and bacteremia *(51)*. Beta-lactam antibiotics are considered as the mainstay of treatment for *S. pneumoniae* infections *(52)*. However, the literature reports an increasing prevalence of AMR among pneumococci, which poses serious therapeutic problems, mainly in the management of pneumococcal meningitis *(53)*. Currently, due to the risk of penicillin-resistance in *S. pneumoniae* isolates and because meningitis is a very serious and potentially fatal disease, 3rd generation cephalosporins in the AWaRE "Watch" category are recommended for empiric treatment *(54)*.

Fifty-one countries (73%) (Fig. 2.15) from all WHO Regions reported AST results for BSIs caused by *S. pneumoniae*. It is important to note that for countries where the *S. pneumoniae* minimum inhibitory concentration (MIC) data with no interpretation are collected at central level by the national coordinating centres, GLASS recommends using non-meningitis breakpoints to interpret reported AST results. However, good surveillance practices would involve the tabulation of results using both meningitis and non-meningitis breakpoints for all, irrespective of the individual patient diagnoses.

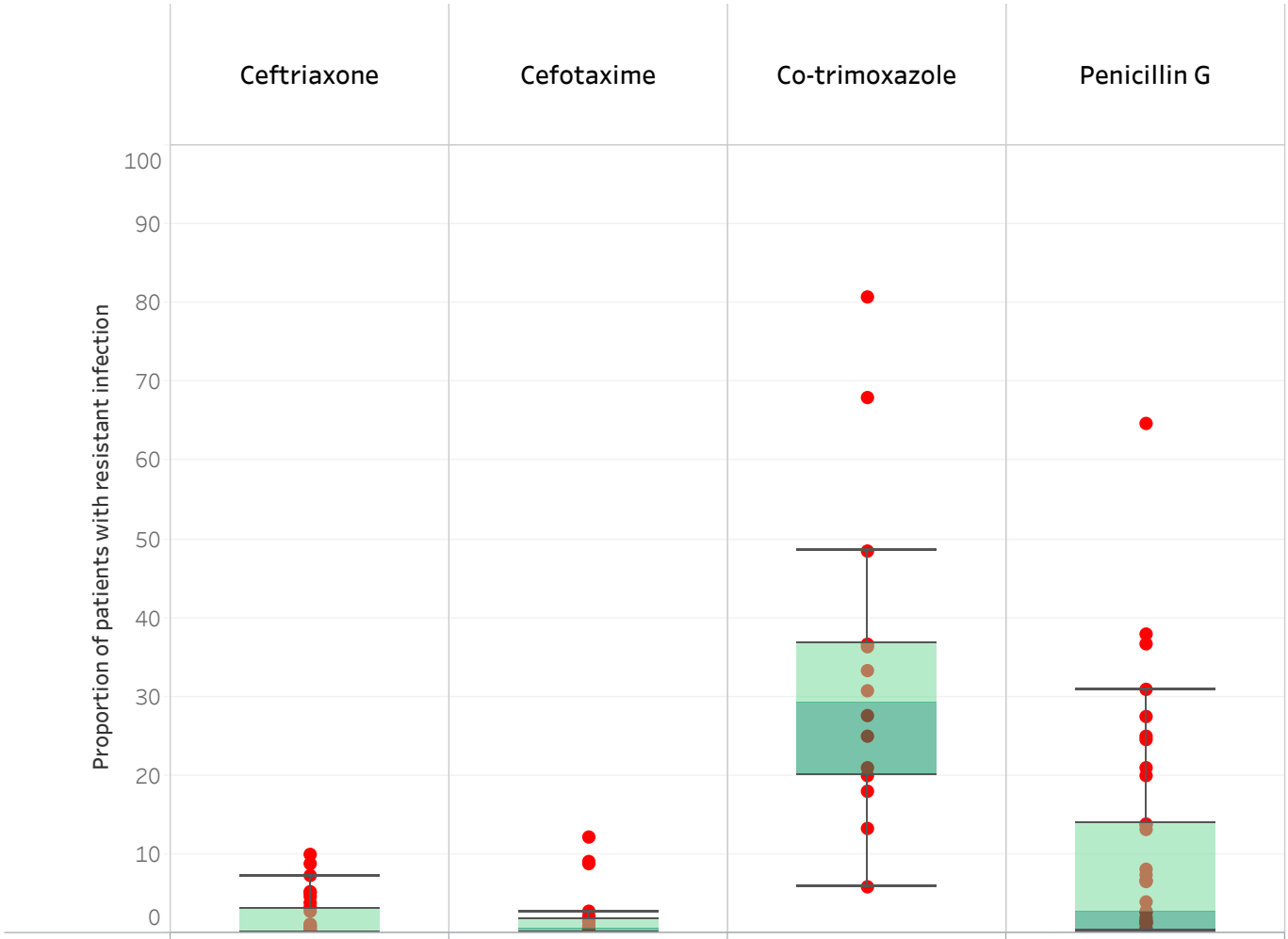
Reported median AMR rates were 2.7% (IQR 0.3-13.8) for penicillins, 0.2% (IQR 0-3) for cefotaxime and 0.5% (IQR 0-1.6) for ceftriaxone, both 3rd generation cephalosporins, and 29.2% (IQR 20-36.7) for fluroquinolones. Although the reported rate for co-trimoxazole may look rather high compared to the other reported antibiotics, the much lower number of patients tested and reporting countries might play a role together with other potential confounding factors and should be further investigated. Data on rates of penicillin- and 3rd generation cephalosporin-resistant *S. pneumoniae* isolates remain scarce in countries with a high incidence of bacterial meningitis, and the monitoring of AMR trends among pneumococcal isolates can help to understand the role of antibiotic therapy practices in the emergence of resistance and to revise the empiric therapy guidelines for pneumococcal disease *(53-55)*.

Fig. 2.14. Proportion of patients with BSIs caused by resistant *Salmonella* spp



	Ceftriaxone	Ceftazidime	Cefotaxime	Ciprofloxacin	Levofloxacin	Meropenem	Imipenem	Ertapenem	Doripenem
Reporting countries *(n)*	26	24	21	32	12	24	23	17	1
Patients with AST results *(n)*	11 009	3 034	4 353	11 483	1 329	4 890	7 719	1 742	18

Fig. 2.15. Proportion of patients with BSIs caused by resistant *S. pneumoniae*



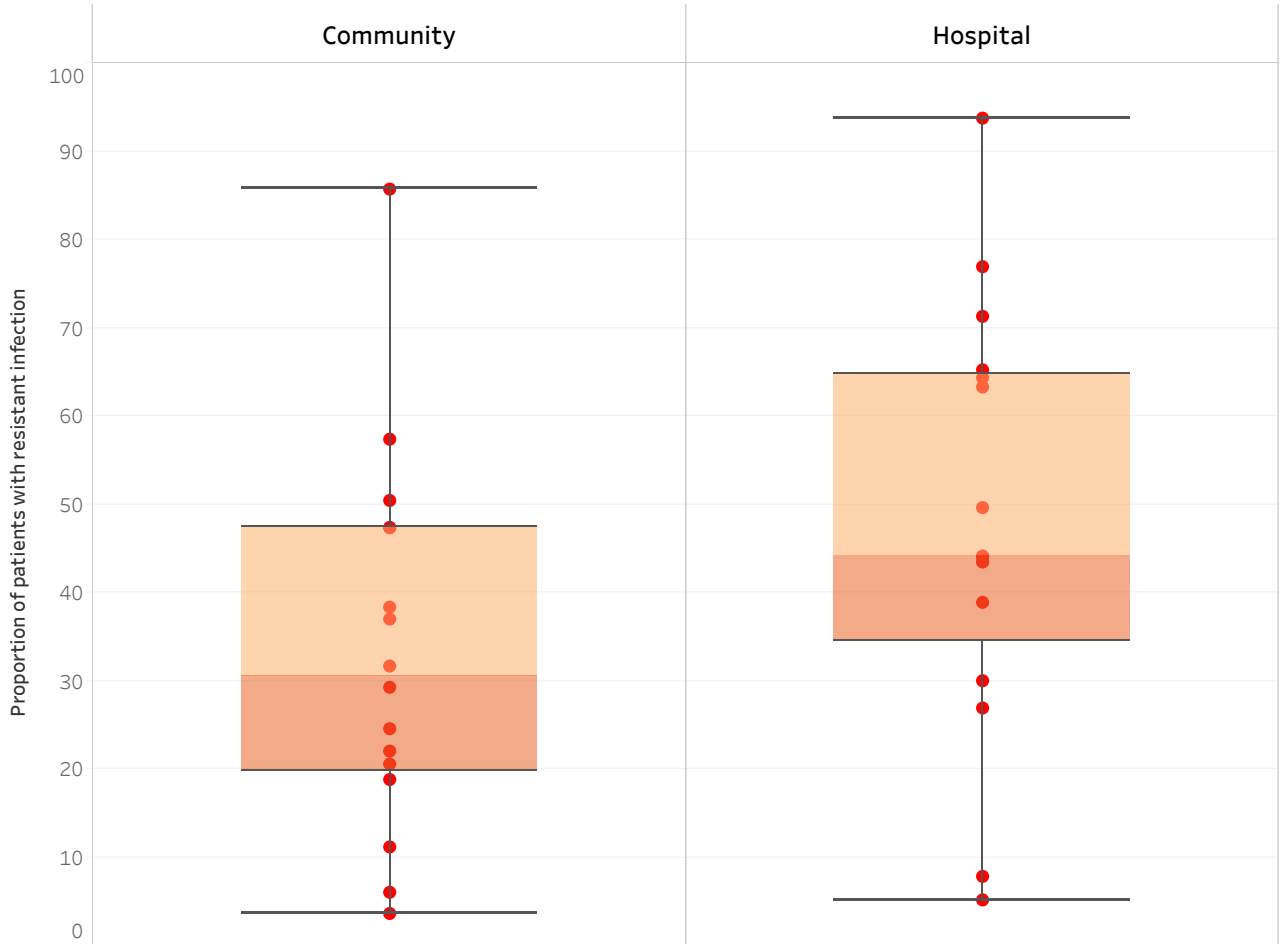
	Ceftriaxone	Cefotaxime	Co-trimoxazole	Penicillin G
Reporting countries *(n)*	31	25	14	38
Patients with AST results *(n)*	10 006	11 678	2 290	18 995

2.2.3.2 Urinary tract infections

According to the Global Burden of Disease study, there were an estimated 274 million new cases of UTIs globally in 2017, across all ages and both sexes *(56)*. GLASS collects data on UTIs caused by *E. coli* and *K. pneumoniae*. For both pathogens, reported resistance (Figs. 2.20, 2.21) to co-trimoxazole, a first-line antibiotic to treat lower UTI, and to ciprofloxacin was found to be consistently high: 43.1% (IQR 22.5-58.6) for *E. coli* and 36.4% (IQR 28.5-52.3) for *K. pneumoniae*. Similar results were found for levofloxacin, the other fluoroquinolone monitored by GLASS for UTIs. Ciprofloxacin is a commonly prescribed fluoroquinolone for UTIs due to its oral availability *(57)*. The high level of resistance to this antibiotic is consistent with reports in the literature alerting that the misuse and overuse of antimicrobials is accelerating this process *(1)*. This is a crucial issue as fluoroquinolones have an important role in the treatment of more severe infections, such as septicaemia, and therefore resistance to fluoroquinolones can have serious clinical consequences *(58)*.

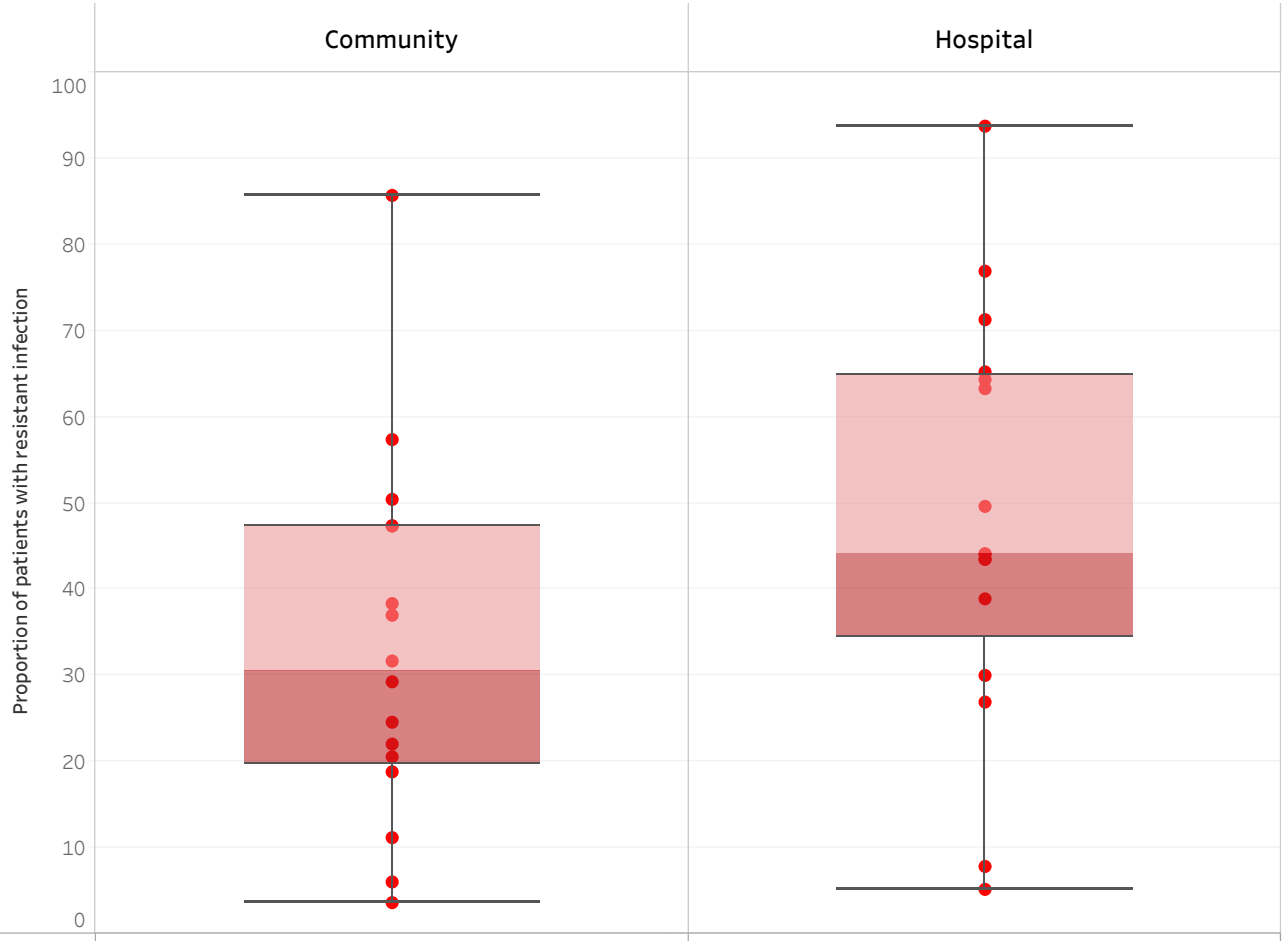
The median resistance reported for to co-trimoxazole is also high: 54.4% (IQR 36.5-69.4) for *E.coli* and 43.1% (IQR 31.8-57.5) for *K. pneumoniae*. Moreover, when looking at the infection origin among countries that reported both community and hospital origins of UTIs (Figs. 2.16, 2.17, 2.18, 2.19), the median resistance rates to ciprofloxacin and co-trimoxazole for the two origins are very high for both *E. coli* and *K. pneumoniae*. Surprisingly, the community results appear quite high (36.4% and 30.5%, respectively) and more data need be generated to inform stewardship programmes and monitoring.

Fig. 2.16. Proportion of patients with UTIs caused by *E. coli* resistant to ciprofloxacin by infection origin



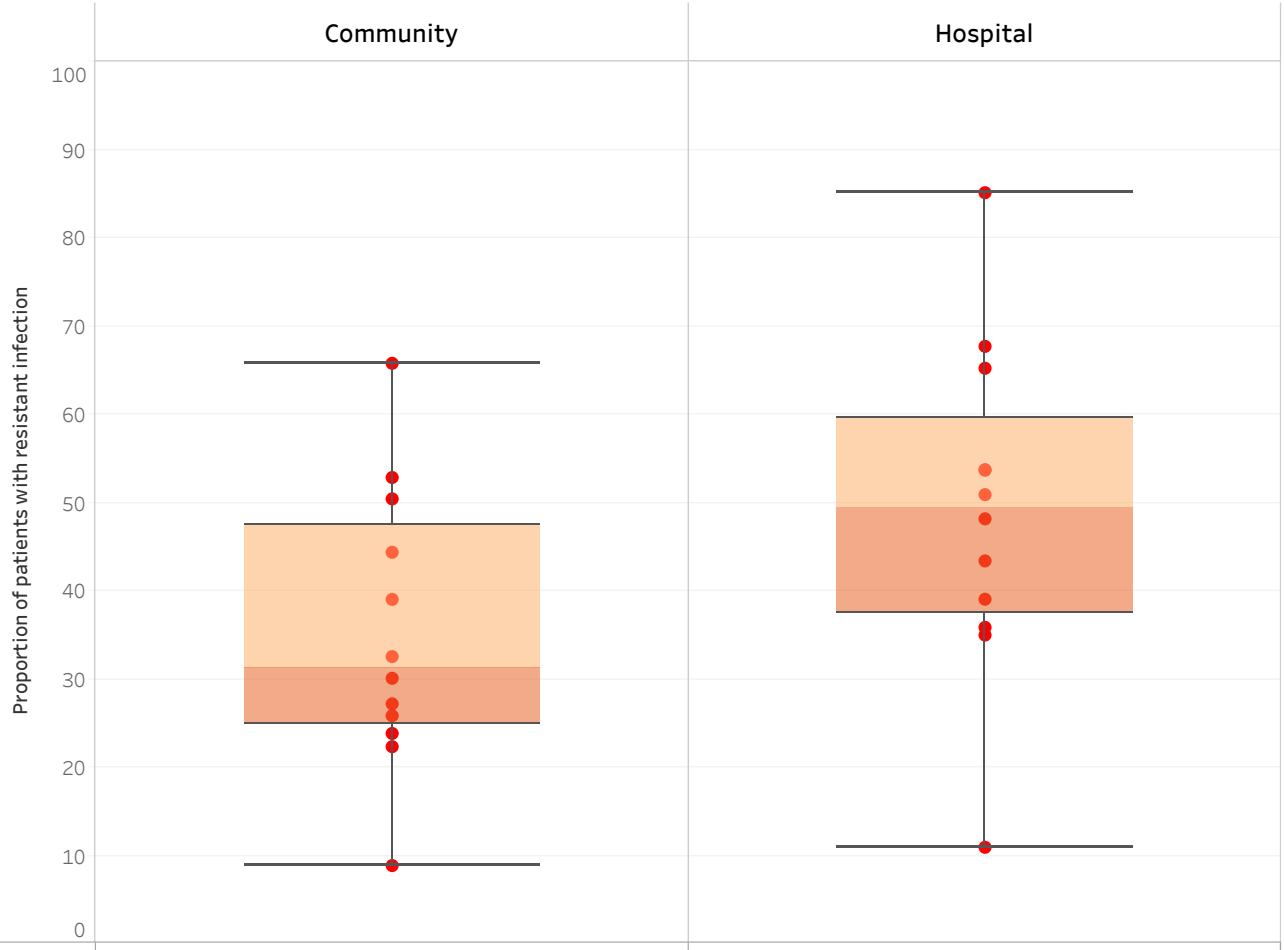
	Community	Hospital
Reporting countries *(n)*	16	28
Patients with AST results *(n)*	267 553	102 829

Fig. 2.17. Proportion of patients with UTIs caused by *K. pneumoniae* resistant to ciprofloxacin by infection origin



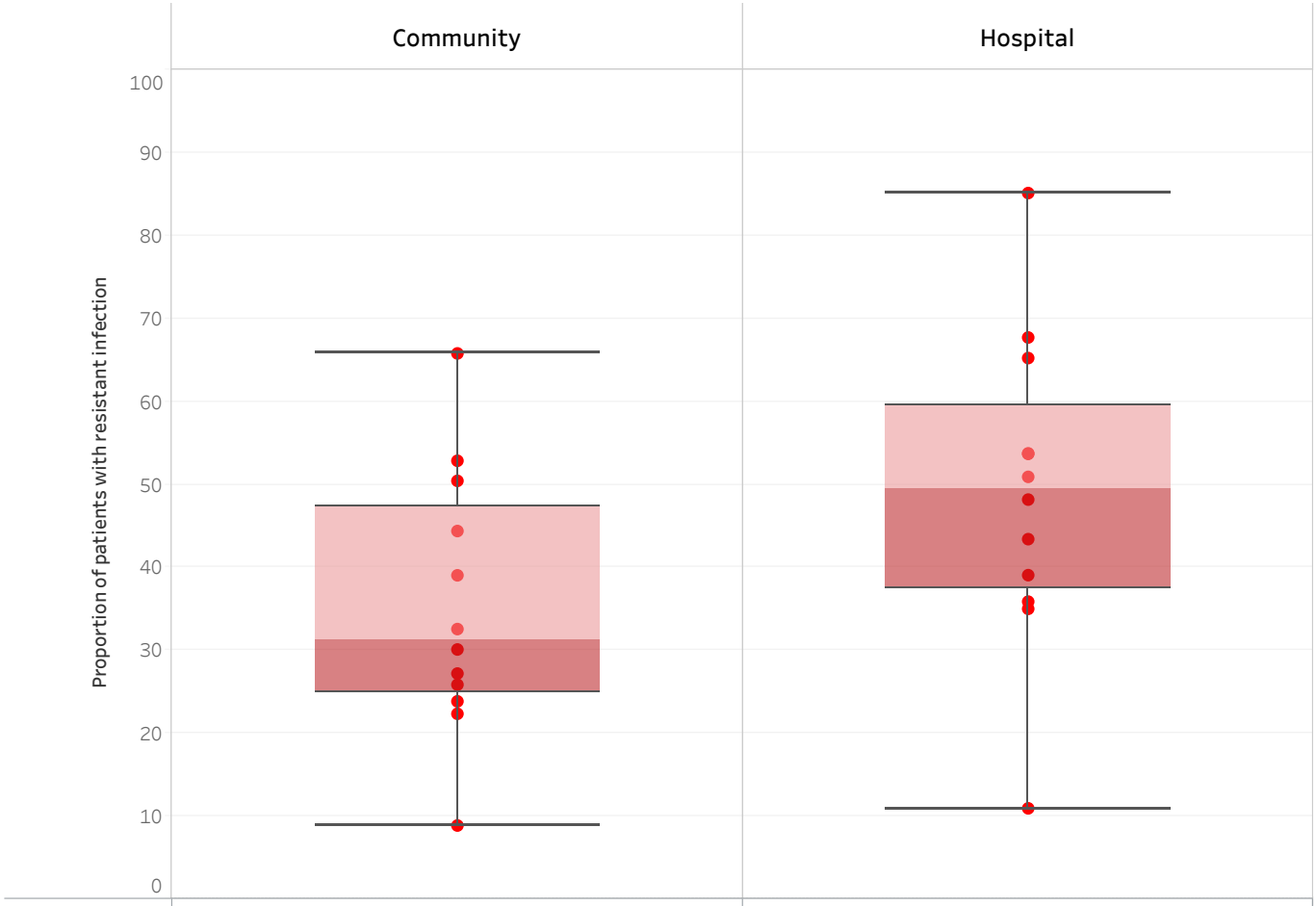
	Community	Hospital
Reporting countries *(n)*	16	16
Patients with AST results *(n)*	46 820	27 343

Fig. 2.18. Proportion of patients with UTIs caused by *E. coli* resistant to co-trimoxazole by infection origin



	Community	Hospital
Reporting countries *(n)*	12	12
Patients with AST results *(n)*	141 212	18 499

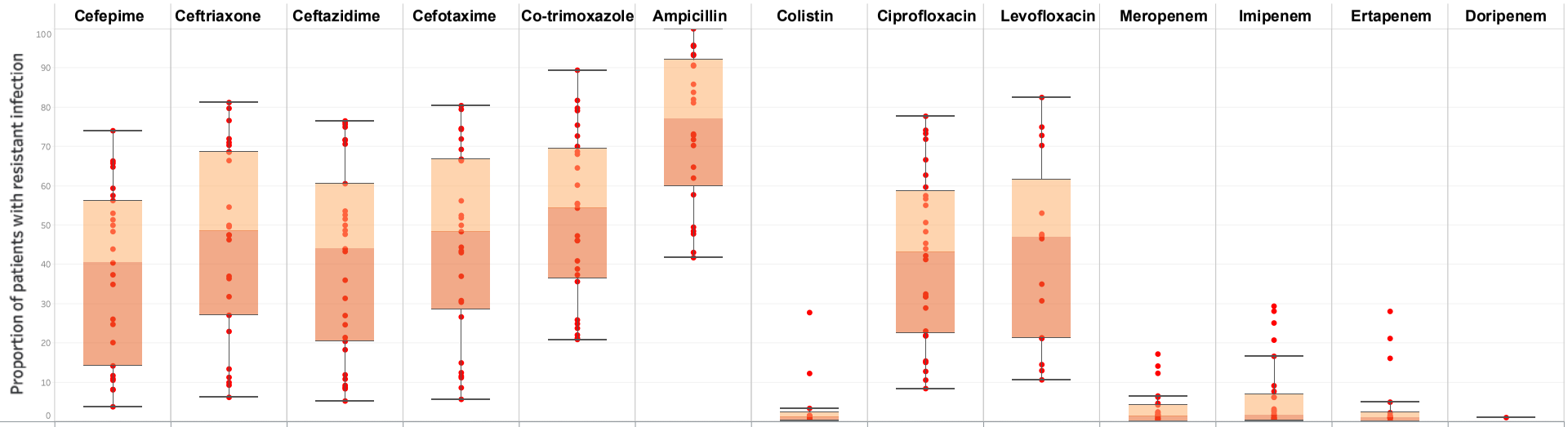
Fig. 2.19. Proportion of patients with UTIs caused by *K. pneumoniae* resistant to co-trimoxazole by infection origin



	Community	Hospital
Reporting countries *(n)*	12	12
Patients with AST results *(n)*	25 023	6 667

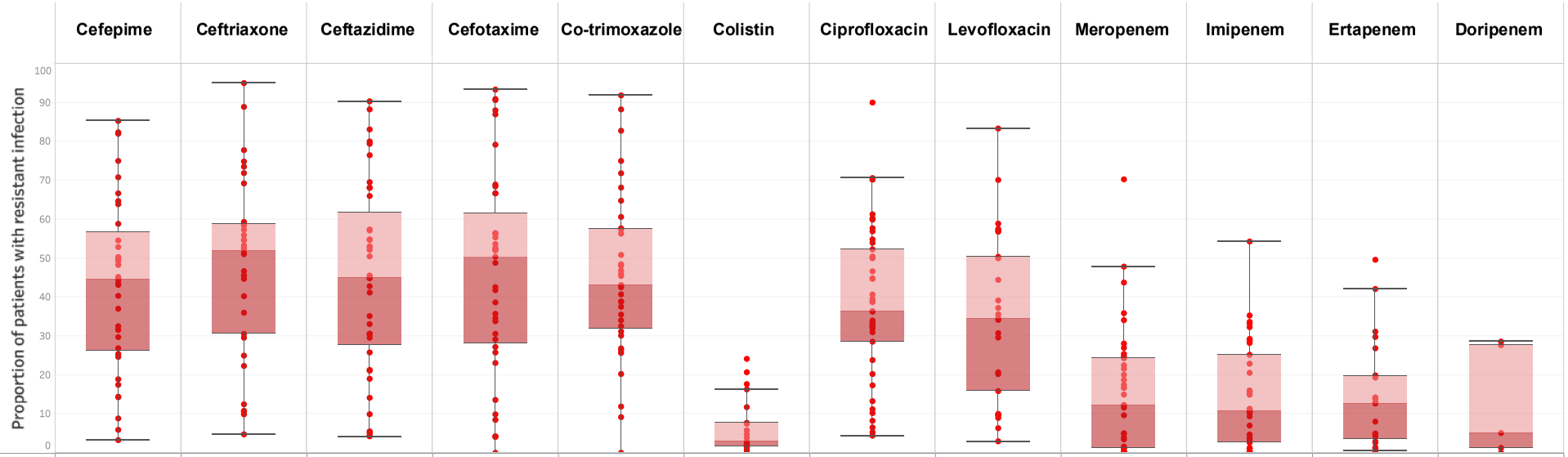
Although the number of countries reporting on BSIs caused by *E. coli* and *K. pneumoniae* resistant to 3rd generation cephalosporin and carbapenems is higher (62 versus 42 for *E. coli* and 62 versus 41 for *K. pneumoniae*, respectively), the median resistance reported for UTI is similar (Figs. 2.20, 2.21). Interestingly, the reported carbapenem resistance is always higher for *K. pneumoniae* compared to *E. coli*. In summary, resistance to carbapenem in UTIs is of general concern and should be carefully monitored. Of note, the detection of colistin resistance poses technical challenges and the picture reported can be misleading as many countries remain unable to accurately identify this type of AMR.

Fig. 2.20. Proportion of patients with UTIs caused by resistant *E. coli*



	Cefepime	Ceftriaxone	Ceftazidime	Cefotaxime	Co-trimoxazole	Ampicillin	Colistin	Ciprofloxacin	Levofloxacin	Meropenem	Imipenem	Ertapenem	Doripenem
Reporting countries *(n)*	25	26	29	27	27	24	12	28	16	25	28	17	1
Patients with AST results *(n)*	815 338	748 780	1 214 715	965 920	733 167	1 568 996	39 083	1 961 032	760 821	1 332 920	803 502	782 471	3 370

Fig. 2.21. Proportion of patients with UTIs caused by resistant *K. pneumoniae*



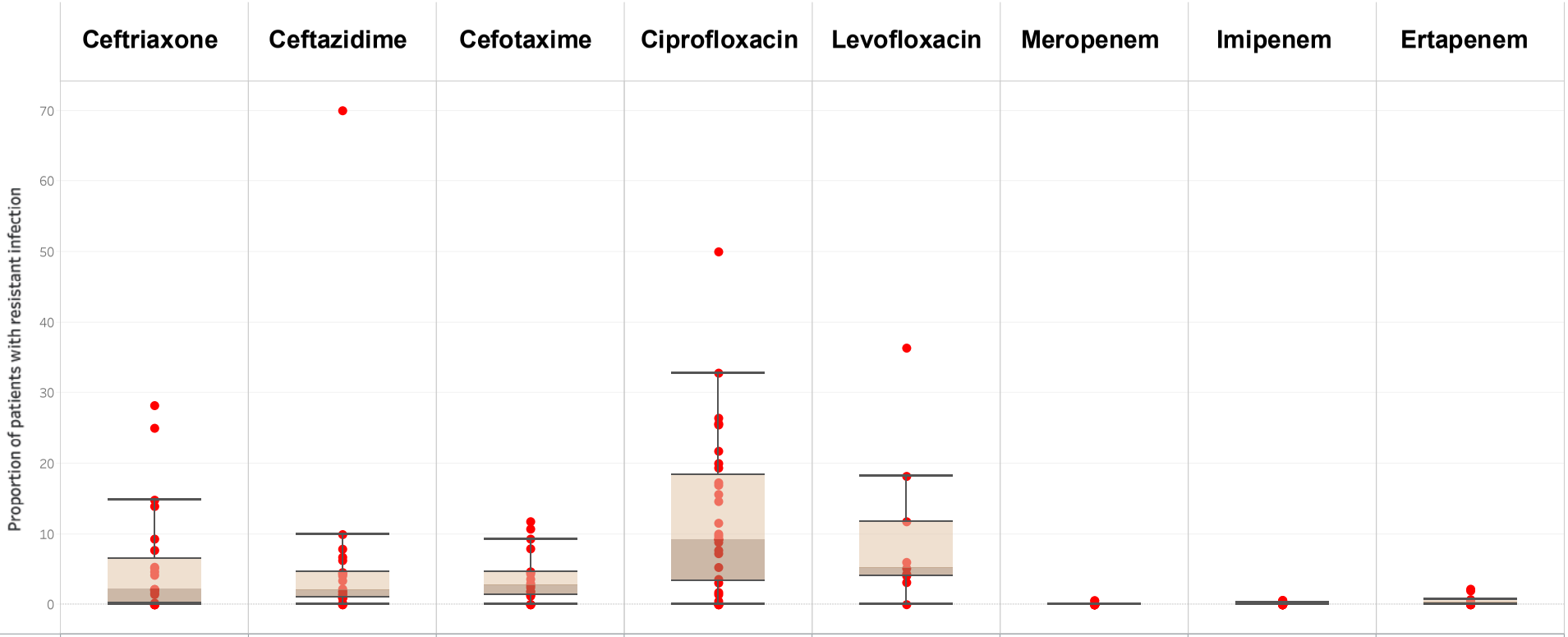
	Cefepime	Ceftriaxone	Ceftazidime	Cefotaxime	Co-trimoxazole	Colistin	Ciprofloxacin	Levofloxacin	Meropenem	Imipenem	Ertapenem	Doripenem
Reporting countries *(n)*	35	34	39	39	35	21	41	25	38	38	24	5
Patients with AST results *(n)*	157 529	140 509	217 223	172 448	132 256	9 007	251 266	143 346	231 790	164 240	114 887	791

2.2.3.3 Gastrointestinal infections

GLASS collects data on *Shigella* spp. and *Salmonella* spp. in stool specimen. In settings with a high risk of fluoroquinolone resistance, 3rd generation cephalosporins, such as cefixime or ceftriaxone, can be used, depending on availability. Data on ciprofloxacin resistance in *Salmonella* spp. were collected for 43% of reporting countries (Fig. 2.22), and median resistance was 9.3% (IQR 3.3-18.2). As expected, data on levofloxacin resistance in *Salmonella* were similar, although fewer countries (15%) contributed to the picture. In *Shigella* spp., ciprofloxacin median resistance was slightly higher (19.4% [IQR 7.3-31.9]), but it was also reported by a smaller number of countries (Fig. 2.23). For 3rd generation cephalosporins, the reported median resistance was low in *Salmonella* spp. (for ceftriaxone, 2.15% [IQR 0.11-6.50]), while in *Shigella* spp., ceftriaxone resistance was higher (18.5%, [IQR 6.5-34.4]). However, these differences in ceftriaxone resistance need to be further investigated and may arise from a number of factors (for example, income level). Only nine countries reported data on both pathogens.

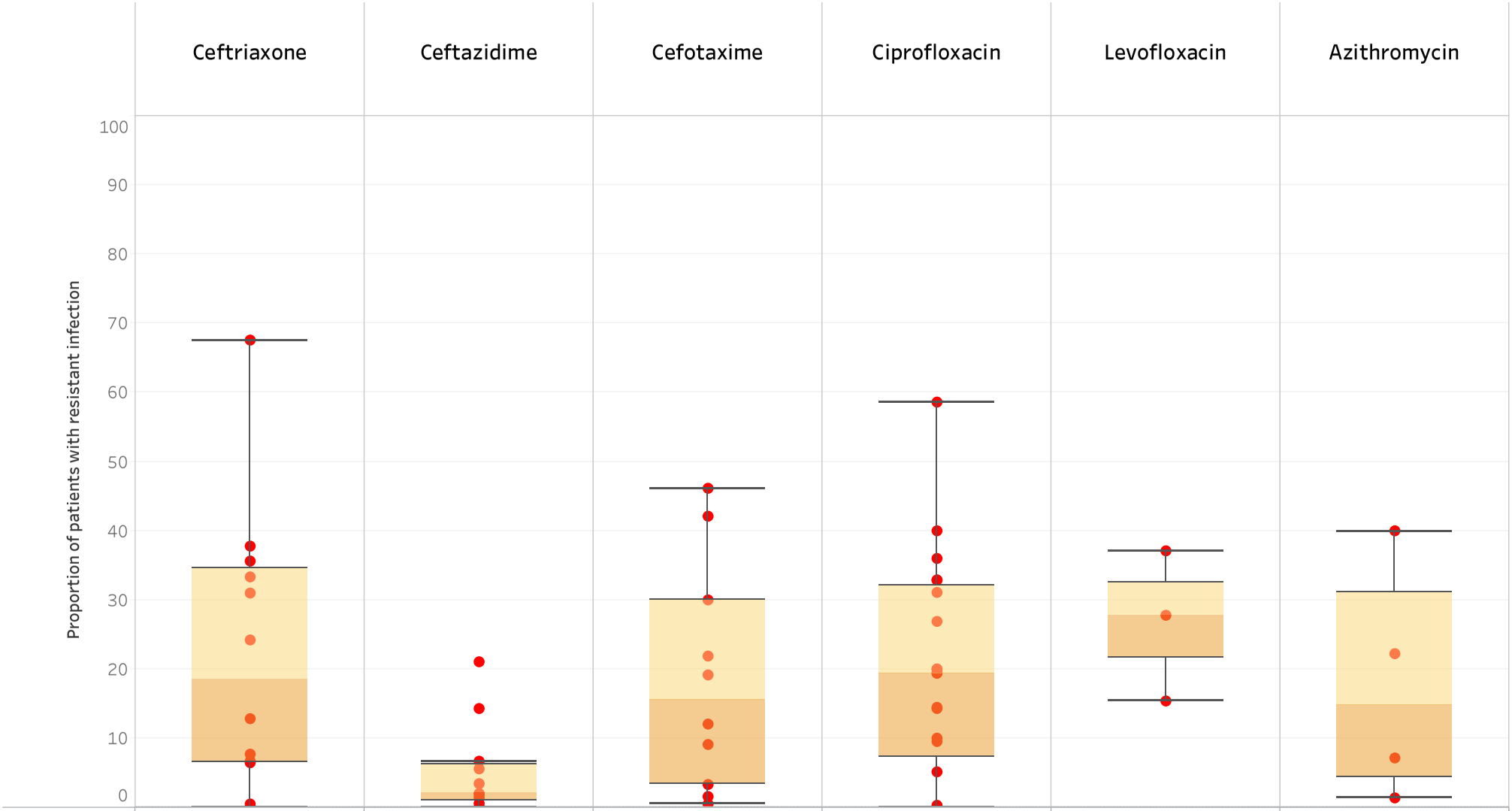
Data showed that the proportion of patients with *Shigella* spp. isolates resistant to ceftazidime is markedly lower than those resistant to cefotaxime and ceftriaxone and could indicate a predominance of ESBL cefotaximases, which could be characterized using molecular tests. Finally, *Shigella* resistance to azithromycin was only reported by 5% of countries. According to the 2016 Global Burden of Disease study, *Shigella* spp. was the second leading cause of diarrhoeal mortality among all ages *(59)*. For acute diarrhoeal disease, the recommended first-line empirical treatment is ciprofloxacin and second line empirical treatment includes 3rd generation cephalosporins and azithromycin. Given the reported resistance, further monitoring of *Shigella* spp. infections should probably be enhanced *(54)*.

Fig. 2.22. Proportion of patients with gastrointestinal infections caused by resistant *Salmonella* spp



	Ceftriaxone	Ceftazidime	Cefotaxime	Ciprofloxacin	Levofloxacin	Meropenem	Imipenem	Ertapenem
Reporting countries *(n)*	23	22	19	31	9	17	19	12
Patients with AST results *(n)*	6 222	5 630	4 547	9 431	1 728	4 364	4 385	2 720

Fig. 2.23. Proportion of patients with gastrointestinal infections caused by resistant *Shigella* spp



	Ceftriaxone	Ceftazidime	Cefotaxime	Ciprofloxacin	Levofloxacin	Azithromycin
Reporting countries *(n)*	12	11	10	20	3	4
Patients with AST results *(n)*	1 183	2 175	2 186	4 229	147	1 537

2.2.3.4 Genital infections

Gonorrhoea is a major global public health concern, but AMR in *N. gonorrhoeae* is seriously compromising the management and control of the spread of infection *(60, 61)*.

The WHO Gonococcal Antimicrobial Surveillance Programme (GASP) has been collating data on gonococcal AMR data from regional initiatives and provided evidence to inform national, regional and global treatment guidelines. Since the launch of GLASS in 2015, WHO-GASP and GLASS methodology are being aligned. Data collection from countries, regional surveillance networks, WHO-GASP and GLASS, is being synergized to increase and stabilize the number of countries reporting data to GLASS. Overall, 37% of countries reported 2019 gonococcal AMR data from genital infections to GLASS. The number of antimicrobials tested varies among countries, similar to the number of reported isolates (ranging from 1 to 5649). The data presented here (Fig. 2.24) are from the 21 countries reporting 2019 gonococcal AMR data to GLASS for at least 10 patients and 10 AST results.

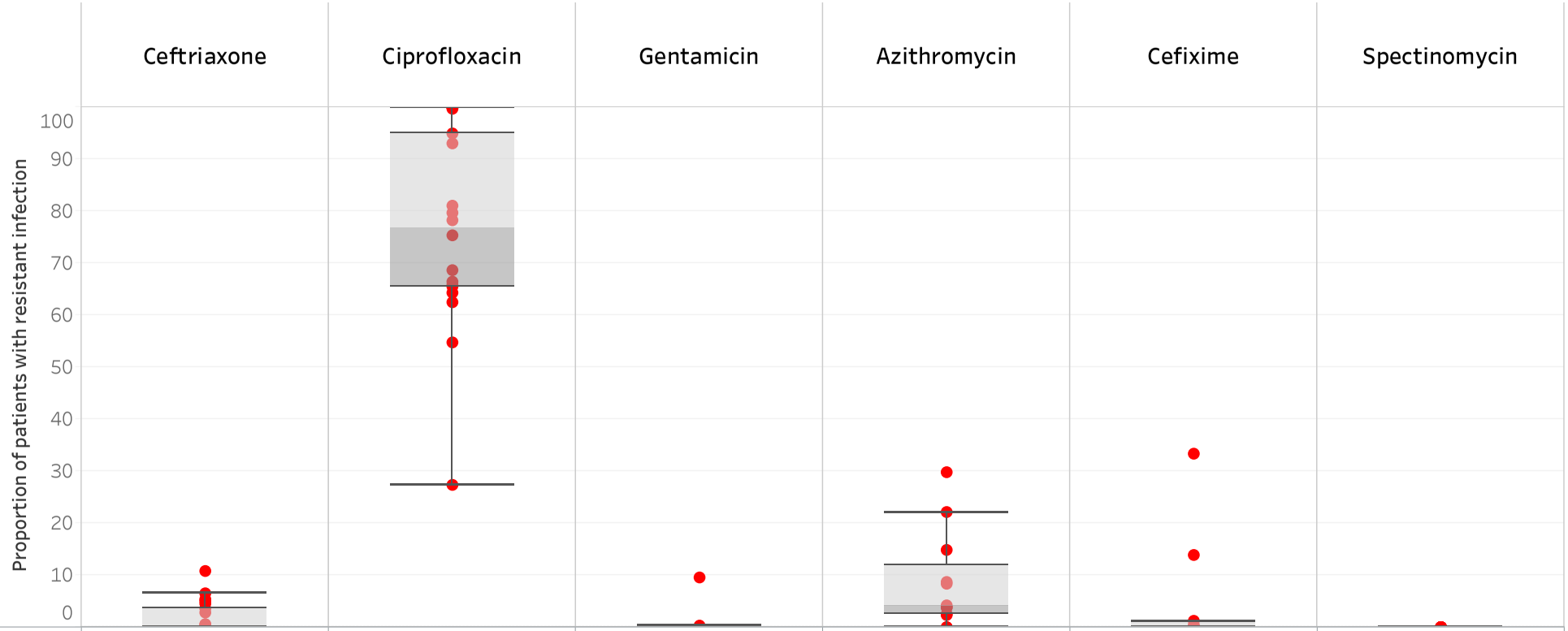
Dual antimicrobial therapy (ceftriaxone plus azithromycin) or high-dose ceftriaxone monotherapy are the last options for empirical first-line treatment of gonorrhoea internationally. Traditionally, first-line empirical treatment has been recommended to be discontinued when the level of treatment failures and/or AMR reaches 5% *(62)*. However, the evidence for this ≥5% AMR threshold is currently being reviewed and modelled by WHO *(63, 64)*.

Overall, 10 out of 21 (47.6%) of countries reported isolates with decreased susceptibility or resistance (DS/R) to ceftriaxone, nine out of 12 (73.3%) with resistance to azithromycin, four out of 12 (33%) countries with DS/R to cefixime, and all to ciprofloxacin. A resistance level ≥5% was observed in four out of 21 (19%) countries for ceftriaxone, five out of 12 (40%) for azithromycin and two out of 12 (14%) countries for cefixime. The proportion of resistance to ciprofloxacin was high in all reporting countries (median resistance 76.8% [IQR 65.7-97.3]). The low numbers of countries reporting gonococcal AMR data to GLASS impede the interpretation of results at regional global level. However, in many countries worldwide, resistance to ciprofloxacin is exceedingly high, azithromycin resistance is increasing, and DS/R to ceftriaxone and cefixime has emerged *(61)*. For this reason, major concerns remain regarding the low numbers of patients tested in many countries, mostly due to either syndromic management or molecular diagnostics.

2.2.3.5 National rates of AMR in the WHO Global Health Observatory

Individual country AMR data are available online on the GLASS page of the WHO Global Health Observatory (https://www.who.int/data/gho/data/themes/topics/global-antimicrobial-resistance-surveillance-system-(glass)). On each country page, a dashboard with a colour-coded system shows the extent of data submission and a table provides an overview of data results. Susceptibility profiles for single antibiotics or antimicrobial classes are presented as bar charts in a "pathogen non-susceptibility overview". Countries that also submitted sampled population data include two further sets of graphics. The first shows the frequency of infection with priority pathogens at different anatomical sites and the frequency of infection by pathogens resistant to specific antibiotics in the tested population. When available, a second set of graphics indicates data on resistance to carbapenems, stratified by age and gender. In the graphs of non-susceptibility, 95% confidence intervals are represented by black lines overlapping the bars. The rules used by GLASS for data analysis in order to ensure the reliability of results are outlined in Annex 7.

Fig. 2.24. Proportion of patients with genital infections caused by resistant *N. gonorrhoeae*



	Ceftriaxone	Ciprofloxacin	Gentamicin	Azithromycin	Cefixime	Spectinomycin
Reporting countries *(n)*	21	18	5	12	12	12
Patients with AST results *(n)*	9 364	8 831	1 704	8 133	2 444	7 486

2.3 GLASS-EAR

GLASS-EAR implements a workflow process for notifying a diverse range of stakeholders on a timely basis of emerging AMR as defined in the GLASS-EAR framework, and in compliance with International Health Regulations (IHR) *(65, 66)*. GLASS-EAR supports prevention, detection, early warning, and risk assessment and response. Importantly, it provides a tool for a standardized, transparent, timely and secure reporting and reactive information sharing.

The GLASS-EAR IT module is a web-based communication platform supporting the rapid and reactive exchange of technical information. Embedded in the GLASS IT platform, it provides a space where GLASS-EAR members can share information regarding emerging AMR events to assess their importance, facilitate early information sharing, and stimulate epidemiological and microbiological discussion for coordinated actions *(67)*. In 2020, the GLASS-EAR team addressed nine events, including one event reported by GLASS national focal points, five reported via IHR channels, and three events through WHO event-based surveillance tools (Table 2.10). In addition, two events were followed up from the previous year.

2.4 GLASS-FUNGI

Few countries have effective surveillance for fungal diseases. Consequently, data on their incidence, resistance and public health impact are limited. GLASS-FUNGI was initiated as a global collaboration to collect data on antifungal-resistant infections in recognition of the growing public health threat of these pathogens. In view of the broad spectrum of invasive antifungal-resistant infections, GLASS work has initially focused on invasive fungal BSI caused by *Candida* spp., the most common type of invasive fungal disease *(68)*. In 2019, the "GLASS Early implementation protocol for inclusion of *Candida* spp." was published *(69)*. To facilitate its implementation in countries, IT tools were potentiated, specifically with a new WHONET configuration and the launch of the fungi IT module on the GLASS platform. The protocol pilot testing phase was initiated in June 2020 with the participation of 26 institutions performing *Candida* spp. analysis. The purpose of this pilot testing is to assess the applicability of the protocol and the capacity of the IT tools to support the inclusion of *Candida* spp. in national AMR surveillance systems. Pilot testing is expected to conclude at the end of 2021 and the results are expected for the first quarter of 2022, including adaptation of tools.

Table 2.10. Summary of events reported by countries, January–December 2020

EVENT		SOURCE
1	First case of *Candida auris* infection in the country.	GLASS focal point
2	Cluster of five cases of *Delftia acidovorans* among hospitalized COVID-19 patients in the terminal stage of illness in a hospital ward.	IHR focal point
3	*Burkholderia aenigmatica* outbreak.	WHO epidemic intelligence
4	Two cases of invasive infections caused by *C. auris* resistant to fluconazole in a public hospital.	IHR focal point
5	First detection of OXA-48 carbapenemase in isolates of *E. coli* and *K. pneumoniae*.	IHR focal point
6	Rise of *C. auris* colonization occurring in public hospitals.	WHO epidemic intelligence
7	Outbreak of infections caused by *C. auris* resistant to amphotericin B and fluconazole among patients hospitalized with COVID-19.	IHR focal point
8	Infections caused by ciprofloxacin-resistant, beta-lactamase-producing *N. meningitidis* serogroup Y isolates.	WHO epidemic intelligence
9	Isolation of vancomycin-resistant *S. aureus*.	WHO epidemic intelligence

2.5 One Health

GLASS-One Health was launched in 2018 and is a WHO integrated multi-sectoral surveillance system based on the ESBL *E. coli* Tricycle project *(70)*. The Tricycle project has identified ESBL *E. coli* as a common indicator to be detected across human samples, poultry, water bodies – specifically sewage, market runoff and river sites in urban areas. Since its creation, the protocol has been piloted in nine Member States (Ghana, India, Indonesia, Jordan, Madagascar, Malaysia, Nepal, Pakistan and Senegal) and is being implemented in five others (Iran, Morocco, Nigeria, Zambia and Zimbabwe) (Table 2.11). Based on the experience gathered in the countries, the final version of the document was published in March 2021 *(71)*. WHO continues to support countries in the implementation of GLASS-One Health and a GLASS module has been developed to allow them to share data of ESBL-producing *E. coli* from the three main sectors.

2.6 Enhanced Gonococcal Antimicrobial Surveillance Programme (EGASP)

EGASP seeks to gather more detailed information on the epidemiology of AMR in N. gonorrhoeae and complements the routine AMR surveillance already reported to GLASS and supported through the WHO GASP *(72)*.

EGASP is a standardized sentinel surveillance of men with suspected urogenital gonorrhoea (that is, presenting with urethral discharge) identified in participating surveillance sites and clinics. Demographic, clinical, and behavioural data are collected during routine clinical activities and urethral specimens are processed in selected reference laboratories using culture techniques, AST, and quality assurance tests. Epidemiological and laboratory data are combined, validated, analysed, and shared with WHO periodically through a dedicated EGASP component in the GLASS-IT platform. The generic EGASP protocol has been published in 2021 and it is available online (http://apps.who.int/iris/handle/10665/341333?locale-attribute=fr&) for countries willing to participate. Countries are responsible for running the programme and receive epidemiological and laboratory support by WHO, WHO Collaborating Centres, and in particular the WHO Collaborating Centre for Sexually Transmitted Infections Prevention (USA-438), based at the United States (US) Centers for Disease Control and Prevention (CDC).

Table 2.11. Countries enrolled and implementing the Tricycle project as of April 2021

REGION	COUNTRIES ENROLLED AND IMPLEMENTING
African	Ghana, Madagascar, Nigeria, Senegal, Zambia, Zimbabwe
Eastern Mediterranean	Iran, Jordan, Morocco, Pakistan, Sudan
South-East Asia	Bhutan, India, Indonesia, Myanmar, Nepal
Western Pacific	Malaysia

EGASP activities are continuing in Thailand and the Philippines where the programme has been implemented since November 2015 and July 2018, respectively *(18)*. Results from the implementation of EGASP in Thailand and the Philippines are shown in Boxes 1-2. The programme started expanding in 2020 with implementation in Cambodia, where the EGASP activities are coordinated by the National Centre for HIV/AIDS Dermatology. Ten sentinel clinical settings, six in Phnom Penh and four in the surrounding provinces were appointed as sentinel sites and trained. Unfortunately, the COVID-19 pandemic and related control measures have had a major impact on Cambodia's activities and implementation has also been slow in the other countries; data collection will begin in 2021.

Implementation in Thailand and the Philippines proved that EGASP is a sustainable methodology for enhanced, culture-based AMR surveillance programmes capable of generating quality-assured data that allows to detect emerging AMR, monitor trends reactively, and identify repeated *N. gonorrhoeae* infections and possible treatment failures. Of note, both countries have revised their national treatment guidelines using evidence generated through EGASP. They have also demonstrated that collecting high-quality demographic, behavioural or clinical data is feasible, which has allowed to accumulate a critical mass of data to investigate the association between epidemiological factors and increased risk of resistance, including shifts in MIC values over time. Moreover, as part of the protocol, all *N. gonorrhoea* isolates are stored and available for satellite projects.

EGASP is flexible and allowed the three participating countries to adopt different strategies in selecting sentinel clinics and reference laboratories. At present, EGASP targets only genital infection in men and does not aim at national representativeness. However, these limitations are considered acceptable, given the need for an enhanced surveillance approach that is sustainable in LMICs and can complement routine surveillance data. Availability of the EGASP protocol and surveillance tools, including an IT solution for collecting and reporting EGASP data, will facilitate expanding its implementation in new countries and additional regions. This will enhance the ability to detect emerging AMR and generate evidence reactively to refine gonorrhoea management guidelines and public health strategies and policies in other countries and regions, as well as globally.

THAILAND

EGASP is coordinated in Thailand by the Department of Disease Control in the Ministry of Health. Patients with urethritis have been identified since November 2015 in two clinical settings in Bangkok, and specimens are analysed at two designated reference laboratories, with technical assistance provided by the WHO Collaborating Centre for Sexually Transmitted Infections Prevention (USA-438) for EQA measures. From November 2015 to December 2018, 2484 cases of urethritis were identified and *N. gonorrhoeae* was culture-confirmed in 1425 cases (57.4%).

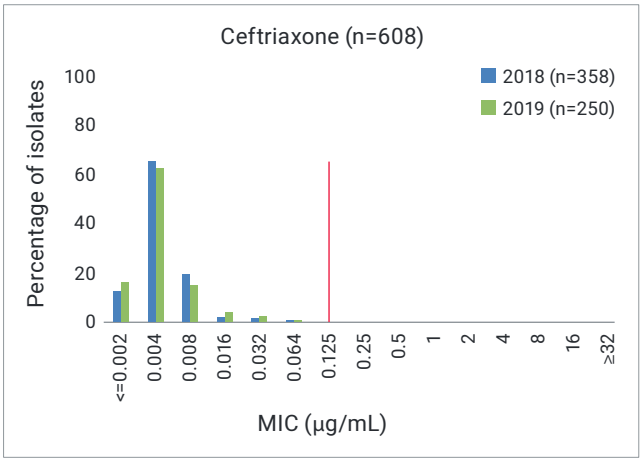
In 2019, 601 additional urethritis cases were identified (Table T.1); 250 (41.6%) were culture-confirmed as *N. gonorrhoeae*. Among the latter cases, 215 persons had at least one episode, 25 of whom had more than one documented *N. gonorrhoeae* diagnosis. All cases were treated with antibiotics according to Thai national guidelines[6]. No treatment failures were identified. No isolates had a final MIC alert value for 3rd generation cephalosporins, azithromycin or gentamicin. Resistance to ciprofloxacin was observed in 89.6% of isolates. Table T.1 and Fig. T.1 summarize results for the period of January 2018–December 2019. Additional data will be summarized and published in a site-led manuscript for a five-year trend analysis.

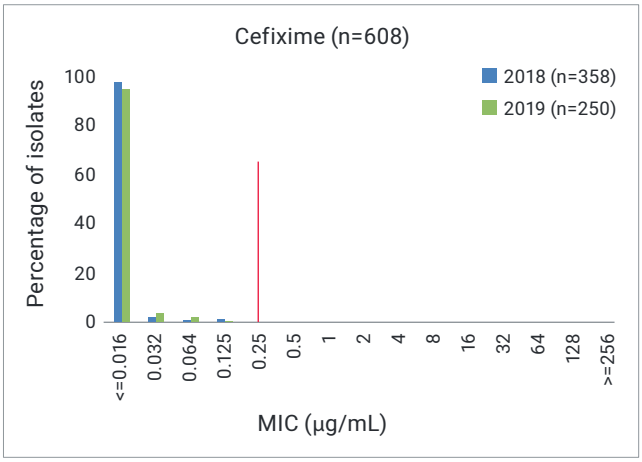
6 Thailand National Treatment Guidelines 2019: first recommendation for gonorrhoea treatment is ceftriaxone 500 mg intramuscularly, together with treatment for nongonococcal urethritis. An alternative treatment is oral cefixime 400 mg, together with treatment for nongonococcal urethritis. Treatment for nongonococcal urethritis includes: azithromycin 1 g oral single dose; doxycycline 100 mg oral dose twice daily after meals for 14 days; roxithromycin 150 mg oral dose twice daily before meals for 14 days; or erythromycin stearate 500 mg oral dose four times daily after meals for 14 days. Available from: http://utoapp.moph.go.th/e_doc/views/uploads/5e4cbc41b41a7-02413010285f714b066770cc26dc5677-779.pdf.

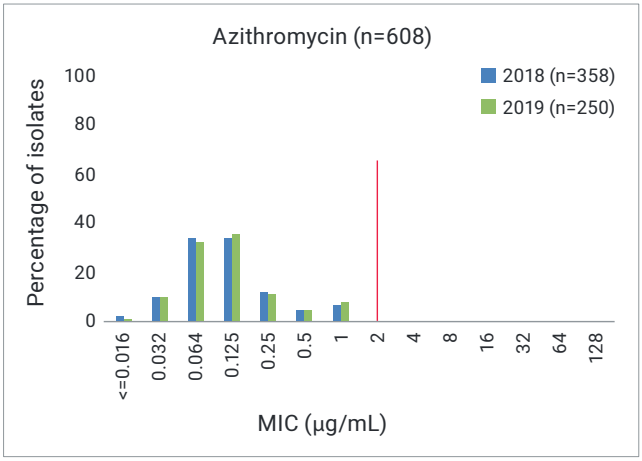
Table T.1. Summary results from EGASP Thailand, January 2018 – December 2019

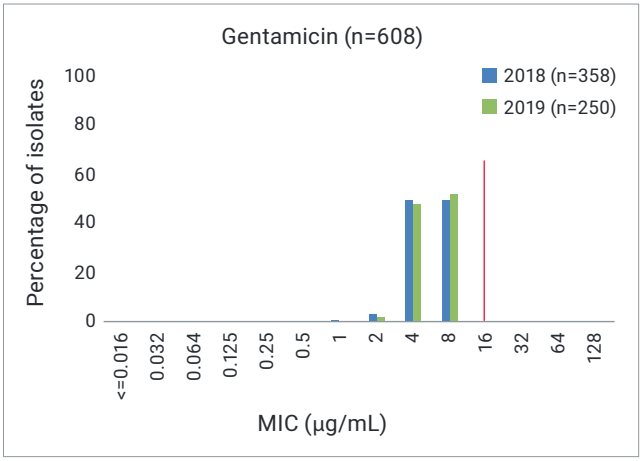
EGASP INCLUSION OVERVIEW	2018		2019	
Urethritis episodes/specimen collected	587		601	
	N (%)			
Gram-stain positive EGASP specimens	361	61.5	258	42.9
Culture-positive/confirmed *N. gonorrhoeae* urethritis	358	61	250	41.6
N. gonorrhoeae isolates with AST results	358	61	250	41.6
Person with at least one *N. gonorrhoeae* urethritis episode	301		215	
Persons with repeated *N. gonorrhoeae* urethritis episodes	33	10.9	25	11.6
Treatment of *N. gonorrhoeae* urethritis episodes	N (%)			
No antibiotic	3	0.4	0	0
Primary treatment				
Ceftriaxone 250 mg	194	54.2	1	0.4
Ceftriaxone 500 mg **	156	43.6	246	98.4
Cefixime 400 mg	1	0.3	1	0.4
Azithromycin 2 g	2	0.6	2	0.8
Other	0	0	0	0
None	5	1.3	0	0
Unknown/refusal	0	0	0	0
Dual treatment for *N. gonorrhoeae* urethritis	N (%)			
Azithromycin 1 g	292	81.6	199	79.6
Azithromycin 2 g	0	0	0	0
Doxycycline 100 mg twice daily 7-14 days	59	16.5	48	19.2
Other	3	0.8	0	0
None	4	1.1	3	1.2
Unknown/refusal	0	0	0	0
Exposure factors at the first *N. gonorrhoeae* urethritis episode	N (%)			
Sexual history: previous three months				
Sex with men	65	21.6	62	28.8
Sex with women	223	74.1	146	67.9
Sex with men and women	13	4.3	5	2.3
Unknown/refusal	0	0	2	1
Antibiotic use in the previous two weeks	75	224.9	35	16.3

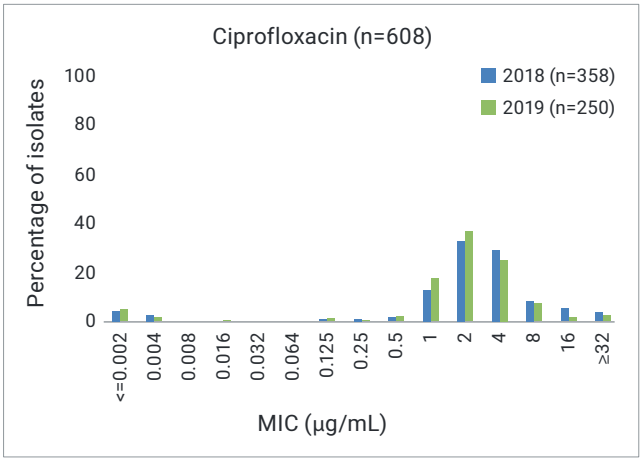
Fig. T.1. Distribution of MICs of *N. gonorrhoeae* isolates, EGASP Thailand, 2018–2019[7]











7. Red lines represent MIC alert values: ceftriaxone MIC ≥ 0.125 µg/mL, cefixime MIC ≥ 0.25 µg/mL, azithromycin MIC ≥ 2.0 µg/mL, gentamicin MIC ≥ 16.0 µg/mL. Red lines represent the Clinical and Laboratory Standards Institute breakpoint for resistance (MIC ≥ 1 µg/mL).

THE PHILIPPINES

EGASP is coordinated in the Philippines by the Department of Health. Cases of urethritis have been identified since July 2018 in four sentinel clinics, all in Metro Manila. Isolates are processed at two designated reference laboratories, with technical assistance provided by the WHO Collaborating Centre for Sexually Transmitted Infections Prevention (USA-438) for EQA measures. From July to December 2018, 226 cases of urethritis were identified, and *N. gonorrhoeae* was confirmed in 161 cases (71.2%).

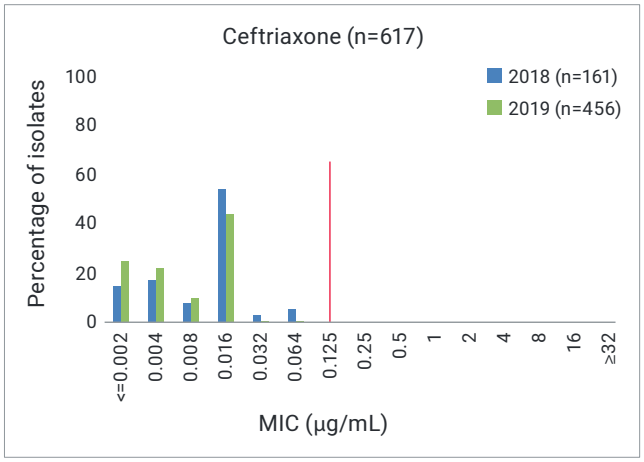
In 2019, 690 cases of urethritis were identified in EGASP. *N. gonorrhoeae* was culture-confirmed in 456 isolates (66.1%). Among the 446 persons with culture-confirmed *N. gonorrhoeae*, 10 persons had more than one confirmed episode. Most cases were among Filipino residents (98%) and median age at the time of diagnosis was 23 years (range 13–71 years). High rates of infection were reported among men who had sex with women (47%). Previous exposure to antibiotics was reported in 14% of confirmed cases; 4% had another sexually transmitted co-infection (for example, chlamydia, HIV/AIDs, herpes, etc.) and 8% had a history of travel (6% had travelled within the country and 2% outside the country). Most cases (97%) were treated with antibiotics and 96% received some form of dual therapy. There were no isolates with a final MIC alert value for 3rd generation cephalosporins, azithromycin or gentamicin. Resistance to ciprofloxacin was observed in 67% of isolates. Table T.2 and Fig. T.2 summarize the results obtained for the period of July 2018–December 2019

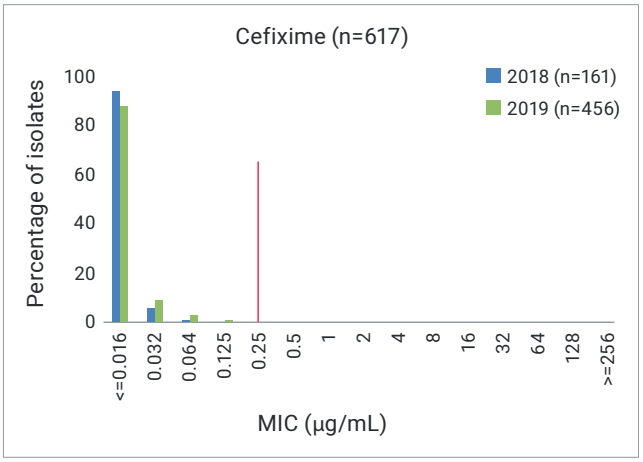
Table T.2. Summary results from EGASP Philippines, July 2018 – December 2019

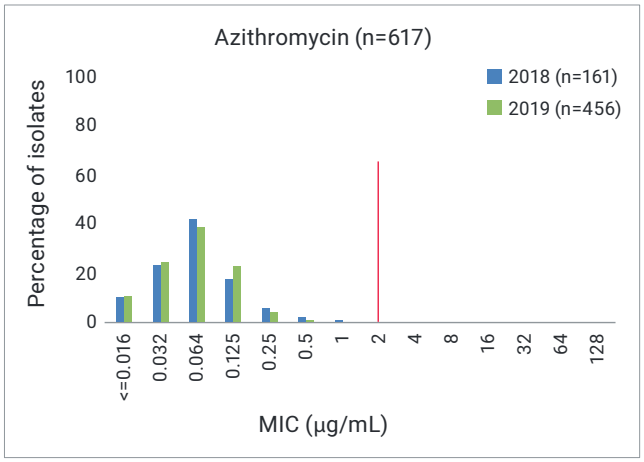
EGASP INCLUSION OVERVIEW	JULY-DECEMBER 2018		2019	
Urethritis episodes/specimen collected	226		690	
	N (%)			
Gram-stain positive EGASP specimens	166	73.5	470	68.1
Culture-positive/confirmed *N. gonorrhoeae* urethritis	161	71.2	456	66.1
N. gonorrhoeae isolates with AST results	161	100	456	100
Person with at least one *N. gonorrhoeae* urethritis episode	158		446	
Persons with repeated *N. gonorrhoeae* urethritis episodes	3	1.9	10	2.2
Treatment of *N. gonorrhoeae* urethritis	N (%)			
No antibiotics	14	8.7	12	2.6
Antibiotic monotherapy	20	12.4	7	1.5
Antibiotic dual treatment	127	78.9	437	95.8
Primary treatment				
Ceftriaxone 250 mg	36	22.4	256	56.1
Ceftriaxone 500 mg	56	34.8	91	20
Ceftriaxone 1 g	39	24.2	58	12.7
Cefixime 400 mg	8	5	30	6.6
Azithromycin 1 g	6	3.7	9	2
Azithromycin 2 g	0	0	0	0
Other	2	1.2	0	0
Unknown/refusal	0	0	0	0

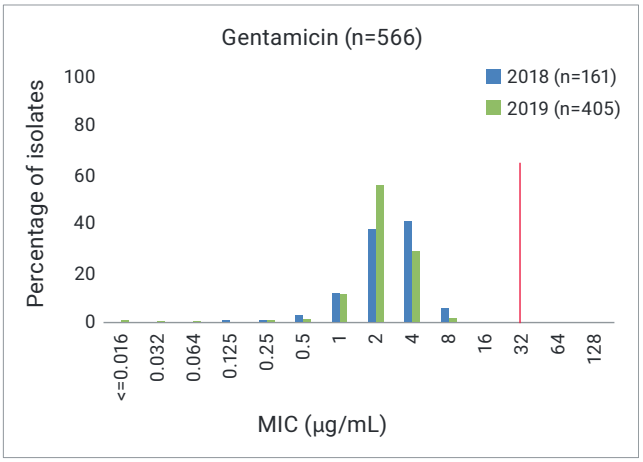
EGASP INCLUSION OVERVIEW	JULY-DECEMBER 2018		2019	
Dual treatment				
Azithromycin 1 g	87	54. 5	370	81.1
Azithromycin 2 g	0	20.5	4	0.9
Doxycycline 100 mg twice daily 7-14 days	33	14.6	58	12.7
Other	7	4.4	5	12.7
Unknown/refusal	0	0	0	1.1
Exposure factors	**N (%)**			
Antibiotic use in the previous two weeks	24	14.9	62	13.6
Presence of other sexually transmitted infection/s	7	4.3	20	4.4
Travel history previous month				
Within country	11	6.8	26	5.7
Outside country	2	1.2	12	2.6
Both	1	0.6	0	0
No travel history	147	91.3	418	91.7
Sexual history: previous three months				
Sex with men	39	24.2	163	35.8
Sex with women	88	54.7	213	46.7
Sex with men and women	34	21.1	80	17.5
Unknown/refusal	0	0	0	0
Sexual behaviour: previous month				
Vaginal	111	68.9	270	59.2
Anal receptive	22	13.7	77	16.9
Anal insertive	64	39.8	181	39.7
Oral receptive	39	24.2	183	40.1
Oral insertive	72	44.7	198	43.4

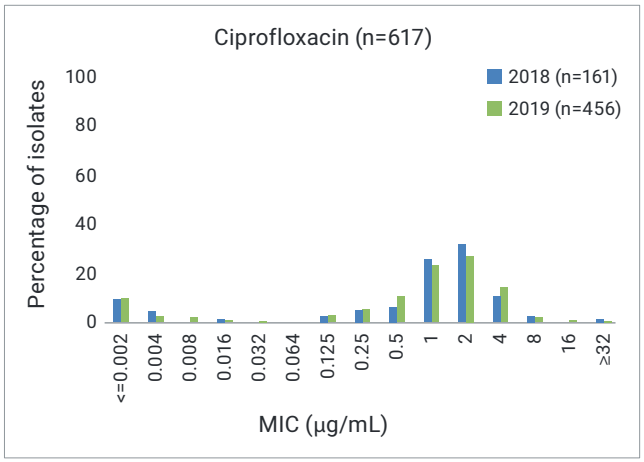
Fig. 2.9. Distribution of MIC values of *N. gonorrhoeae* isolates, EGASP Philippines, July 2018–December 2019[8]











8. Red lines represent MIC alert values: ceftriaxone MIC ≥ 0.125 µg/mL, cefixime MIC ≥ 0.25 µg/mL, azithromycin MIC ≥ 2.0 µg/mL, gentamicin MIC ≥ 32.0 µg/mL. Red lines represent the Clinical and Laboratory Standards Institute breakpoint for resistance (MIC ≥ 1 µg/mL).

2.7 Point prevalence survey of antimicrobial use (PPS-AMU) at hospital level

The WHO PPS-AMU method has been developed with the aim of collecting baseline information on the use of antibiotics in hospitals *(34)*. Patient-level data (that is, indication, appropriate choice, dosing, route, duration) of antibiotic use in hospitals is important to explore prescribing practices and inform antimicrobial stewardship programmes. In addition to assessing the use of antibiotic treatment, the information can be used for improving quality of patient care. The survey can be run at a single hospital, a group of hospitals initiative, or as a wider national project where inclusion criteria and definitions are decided nationally.

To account for challenges associated with data collection in resource-limited settings, the methodology has been developed with flexibility in mind. The methodology proposed is a cross-sectional observational survey where patients are included among those admitted on a specific day in a specific ward of the participating hospital, which constitutes a convenience sampling. Data are collected from medical records and associated patient documentation. A set of core variables has been selected by WHO as necessary for data analysis and interpretation and provides the possibility to implement follow-up activities. As shown in Table 2.13, the PPS-AMU is being implemented in 34 countries in three WHO regions.

2.8 GLASS studies for estimating the AMR burden

Accurate data about the burden that AMR places on the national health and economy are important for governments to reliably and prudently prioritize their public health spending. The assessment of impact on human health is key to inform burden estimates. However, most estimates of the impact of AMR on human health, apart from a few pathogens such as TB, have been based on fragmented and limited data, mainly derived from retrospective epidemiological studies in HICs and often conducted using very different methodological approaches *(73)*.

The health impact of a disease can be measured by using different metrics (for example, mortality, prevalence, incidence) and is generally the combination of different measures to obtain the clearest picture. To harmonize the approach and yield more robust estimates of the impact of AMR, GLASS published in May 2020 the "GLASS method for estimating attributable mortality of AMR bloodstream infections", one of the key metrics needed *(74)*. The tool is a master template protocol aimed at estimating in-hospital mortality - and optionally mortality at 28 days after confirmed infection - attributable to AMR BSI, one of the most serious life-threatening infectious diseases. The protocol is targeting at a minimum *E. coli* resistant to 3rd generation cephalosporins and MRSA bloodstream infections both of community and hospital origin, but it can be applied to other pathogen-antimicrobial combinations based on the local epidemiology and availability of resources. The study design proposed is a prospective cohort study including up to three patient cohorts (patients with AMR BSIs of each target species, drug-susceptible BSIs of each target species and, optionally, patients without BSI of the target pathogen) followed up until hospital discharge and optionally after discharge. The protocol includes the collection of a large number of variables, which will allow for adjustment of confounders and risk factor analysis. The first implementation phase will start in the second quarter of 2021 in selected countries in Africa and South-East Asia through the "A Clinically-Oriented Antimicrobial Resistance Surveillance Network (ACORN)" *(75)*. Launched in 2019 by the Oxford Tropical Network (United Kingdom of Great Britain and Northern Ireland), the concept of ACORN is operationally efficient, case-based AMR surveillance that can be deployed in low resource settings to add value to existing laboratory capacity building efforts. Assuming blood cultures are collected in all patients with suspected BSIs, that is, there is good diagnostic stewardship, then ACORN surveillance is expected to capture all patients eligible for inclusion in the GLASS protocol, and data collected will enable the calculation of attributable mortality for BSIs caused by resistant *E. coli* and *S. aureus* in accordance with the GLASS method. Other external partners, WHO Regional Offices, and GLASS-enrolled countries, have expressed an interest in aligning with and applying the protocol in the coming years.

Table 2.13. Countries implementing the WHO PPS methodology as of 30 April 2021

REGION	COUNTRIES ENROLLED AND IMPLEMENTING
African	Burkina Faso, Burundi, Côte d'Ivoire, Kenya, Madagascar, Malawi, Mali, Mauritius, Mozambique, Nigeria, Republic of the Congo, Sierra Leone, United Republic of Tanzania, Zimbabwe
Americas	Barbados, Belize, Chile, Costa Rica, Cuba, El Salvador, Guyana, Haiti, Mexico, Nicaragua, Paraguay, Peru, St. Lucia
Eastern Mediterranean	Iraq, Jordan, Lebanon, Pakistan, Sudan, Tunisia, United Arab Emirates


SECTION
03

3. Global AMR surveillance of other pathogens and regional activities

3.1 Global AMR surveillance of other pathogens

3.1.1 Surveillance of HIV drug resistance

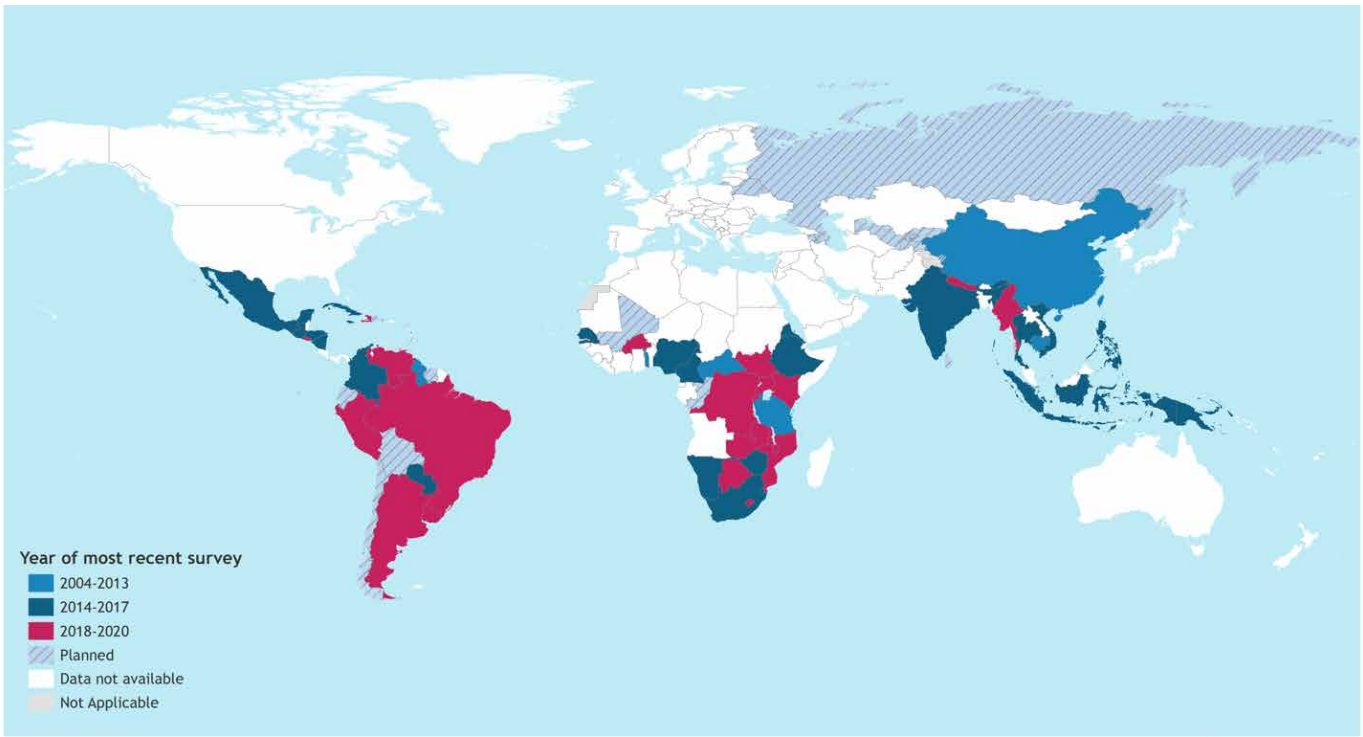
The emergence and transmission of some level of HIV drug resistance is inevitable, even when appropriate regimens are prescribed and adherence to treatment is optimal. To address this challenge, WHO launched a Global Action Plan on HIV drug resistance in 2017, aligned with the WHO GAP-AMR *(76)*. The Global Action Plan on HIV drug resistance has strategic objectives and a framework for action representing five key pillars: (1) prevention and response; (2) monitoring and surveillance; (3) research and innovation; (4) laboratory capacity; and (5) governance and enabling mechanisms. This comprehensive approach relies on obtaining and using quality data on HIV drug resistance.

The surveillance of HIV drug resistance provides countries with evidence that can be used to inform national HIV treatment guidelines and optimize patient and population-level treatment outcomes. WHO recommends implementing surveillance of HIV drug resistance in adults and children including:

- surveillance of **acquired** HIV drug resistance in adults and children receiving antiretroviral treatment *(77)*;
- surveillance of **pre-treatment** HIV drug resistance among treatment-naive infants newly diagnosed with HIV *(78)*;
- surveillance of **pre-treatment** HIV drug resistance among adults initiating first-line antiretroviral treatment *(79)*;
- surveillance of HIV drug resistance among individuals using **pre-exposure prophylaxis** who are diagnosed with HIV *(80)*.

Between 2004 and 2020, 57 LICs and LMICs implemented 214 surveys of HIV drug resistance using WHO-recommended standard methods. A further 17 countries have plans to conduct surveys (Fig. 3.1).

Fig. 3.1. Implementation of HIV drug resistance surveys, 2004–2020



The WHO HIV Drug Resistance Network (HIVResNet) supports HIV drug resistance surveillance by providing timely, accurate and quality-assured genotypic data, following specifications described in the WHO HIVResNet Laboratory Operational Framework *(81)*. As of November 2020, the Network comprises 34 laboratories at national, regional and specialized levels, which are designated by WHO to genotype specimens collected from national surveys (Fig. 3.2). Fifteen laboratories have the capacity to genotype from dried blood spot specimens, a field-friendly specimen type most suitable for use in many LMICs *(82)*. In addition, five laboratories have received a formal designation by WHO to test for resistance to integrase inhibitors, a new class of antiretrovirals.

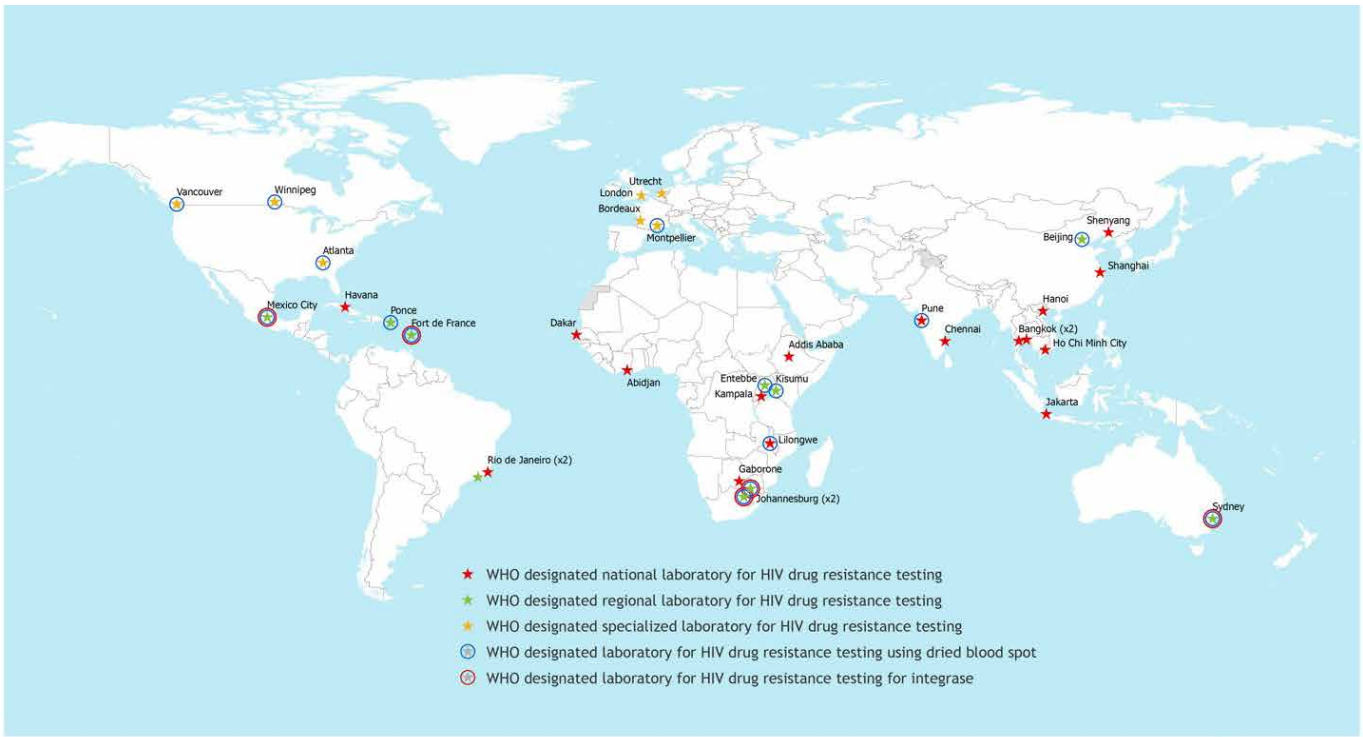
Countries are encouraged to ensure the timely interpretation and dissemination of HIV drug resistance data to inform nation and global policies. WHO has developed a global repository of HIV drug resistance survey data *(83)*. Individual level sequences and epidemiological data are entered and stored in the WHO HIV drug resistance database for three main purposes: (1) quality assurance; (2) to ensure a standardized interpretation of resistance by linkage to the most recent interpretation algorithm; and (3) to provide a long-term, secure repository for data on resistance to HIV drugs.

WHO regularly produces global reports on HIV drug resistance to reflect new national survey data as it becomes available. The 2019 global report on HIV drug resistance showed that up to 26% of people initiating treatment are infected with an HIV virus carrying resistance to first-line drugs (such as efavirenz) and that very high levels of HIV drug resistance – up to 69% – are seen in infants born to mothers infected with HIV *(84)*. The report also showed that up to 95% of people failing HIV treatment carry a drug resistance virus. These data emphasize the need to fast-track the transition to the WHO-recommended dolutegravir-based treatment.

3.1.2 Surveillance of resistance to anti-TB drugs

The Global Project on Anti-TB Drug Resistance Surveillance, supported by a global network of WHO Supranational TB Reference Laboratories, is the oldest and largest project for the surveillance of AMR in the world *(85)*. Since its launch in 1994, data on drug resistance have been systematically collected and analysed from 169 countries worldwide. Data are derived from either continuous surveillance systems based on routine drug susceptibility testing in at least 80% of patients with bacteriologically confirmed TB or periodic epidemiological surveys of representative samples of patients *(85)*.

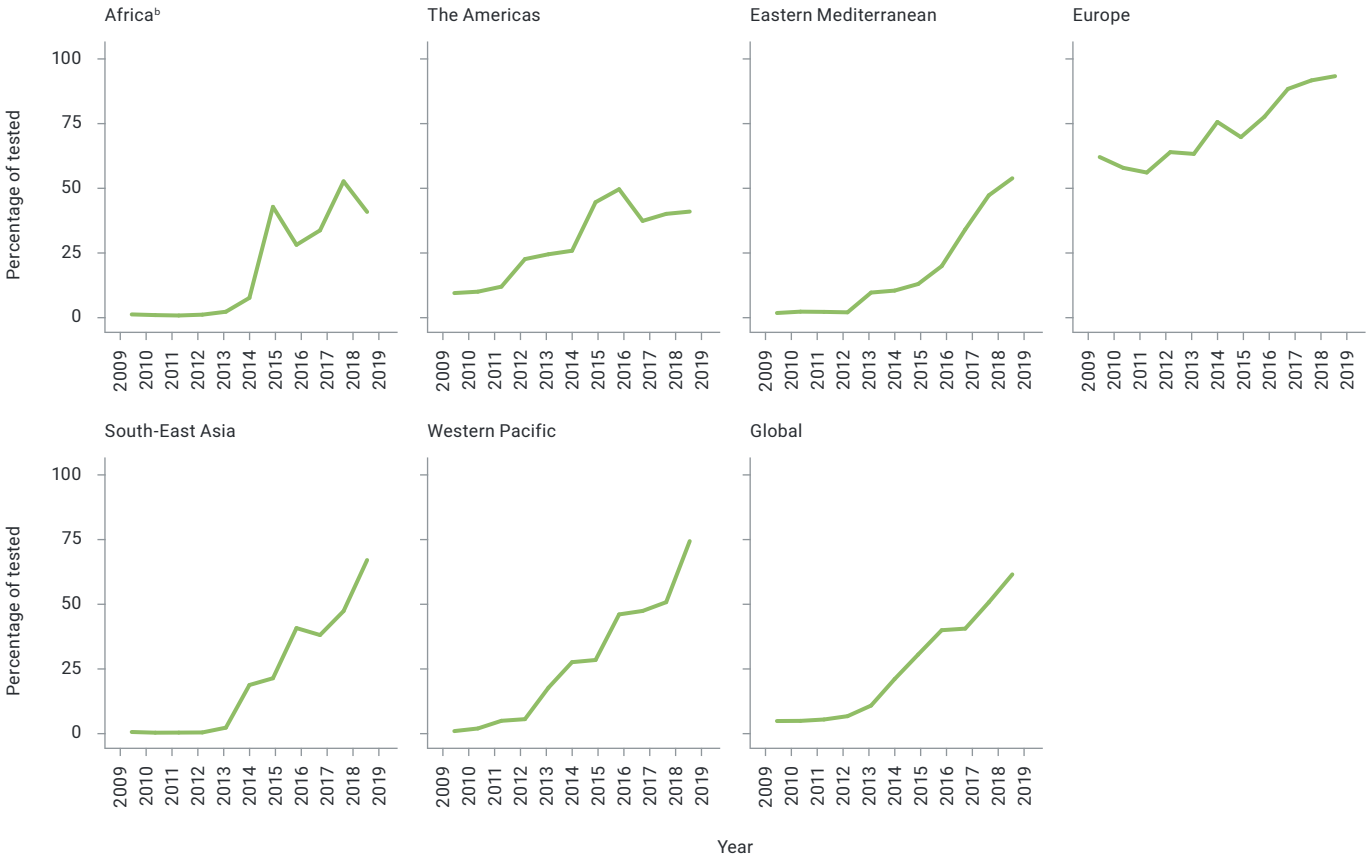
Fig. 3.2. WHO HIV Drug Resistance Laboratory Network, November 2020



The three main categories used for global surveillance are: rifampicin-resistant (RR) TB either with concurrent isoniazid resistance (multidrug-resistant-TB [MDR-TB]) or without; isoniazid-resistant TB (Hr-TB) without concurrent rifampicin resistance; and additional resistance to fluoroquinolones among these groups, which forms a critical component of the recommended treatment regimens for both MDR/RR-TB and Hr-TB. Revised definitions for pre-extensively drug-resistant (pre-XDR) TB and XDR-TB are being applied from 2021. Pre-XDR-TB refers to combined resistance to rifampicin and a fluoroquinolone[9]. XDR-TB refers to combined resistance to these drugs, as well as resistance to at least one group A drug recommended for the treatment of MDR/RR-TB (bedaquiline or linezolid).

There has been considerable progress in improving the coverage of drug susceptibility testing with the global expansion of rapid molecular tools (Fig. 3.3), which have allowed an increasing number of countries to transition from a reliance on periodic surveys to the establishment of continuous surveillance systems based on routine drug susceptibility testing. In 2019, 61% of people with bacteriologically-confirmed TB were tested for rifampicin resistance, an increase from 51% in 2017 and 7% in 2012. In addition, 113 countries achieved good routine drug susceptibility testing coverage (>80%) for rifampicin, compared to only 80 countries in 2015. This included 17 of the 40 countries in WHO's list of high TB and/or high MDR-TB burden countries for the period 2016–2020. Of the MDR/RR-TB cases detected in 2019, 71% were tested for resistance to fluoroquinolones, compared with 65% in 2018. Despite these improvements in drug susceptibility testing coverage, only 44% of estimated MDR/RR-TB cases were notified in 2019 and only 38% of these countries were enrolled in second-line treatment. Drug susceptibility testing coverage for isoniazid and fluoroquinolones remained low. Closing these gaps will require further strengthening of laboratory capacity, sample transport systems, and data connectivity solutions *(85)*.

Fig. 3.3. Percentage of bacteriologically-confirmed TB cases tested for RR-TB globally[a] and by WHO region, 2009–2019



a Includes both new and previously treated TB cases; data for 2017 onwards are for pulmonary TB cases only.

b The increase in the African Region from 2014 to 2015 was due to a large increase in reporting of laboratory results for cases in South Africa in 2015.

9 Moxifloxacin and levofloxacin are the only fluoroquinolones currently recommended for the treatment of MDR/RR-TB. Phenotypic drug susceptibility testing of these two drugs correlate well when tested at the recommended critical concentrations.

3.1.3 Surveillance of antimalarial drug efficacy

Antimalarial drug resistance is a major public health problem and challenges our ability to control the disease. To respond to the emergence of resistance to antimalarial drugs, WHO is helping countries to limit the impact of resistance by supporting studies investigating drug efficacy and resistance, in addition to setting up a global database containing data from published and unpublished studies related to therapeutic efficacy, and surveys of molecular markers of antimalarial drug resistance.

In November 2020, WHO published the "Report on antimalarial drug efficacy, resistance and response, 10 years of surveillance (2010–2019)" *(86)*. This report provides an overview of the tools currently used to monitor drug efficacy and resistance, including a summary of activities needed to minimize any public health impact of antimalarial drug resistance, and reviews data collected from 2010–2019 in the WHO global database on antimalarial drug efficacy and resistance. Additionally, the latest available data are available online in the WHO Malaria Threats Map (https://www.who.int/teams/global-malaria-programme/surveillance/malaria-threats-maps).

WHO is continuously updating standard protocols for monitoring the efficacy of antimalarial medicines in all transmission areas. The protocols are designed to enable the generation of essential information on efficacy for a range of antimalarial drugs against uncomplicated malaria, and to ensure a sufficient evidence base for use by ministries of health to establish informed treatment policies and guidelines. WHO currently recommends monitoring the efficacy of first- and second-line treatments every two years at all sentinel sites and changing the antimalarial treatment policy when the treatment failure rate exceeds 10% at 28- or 42-day follow-up (depending on the drug). Changes in the prevalence of genetic mutations associated with resistance can be used as early signals of the emergence of resistance and also used to confirm that treatment failure is due to resistance.

Overall, where tested, first- and second-line treatments are efficacious for *Plasmodium falciparum*. Where high treatment failure rates were reported, policy changes have been made or are ongoing. Of note, high rates have been detected with dihydroartemisinin-piperaquine in four countries in the Greater Mekong subregion (GMS) – Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam. Overall, in the GMS, there are still at least two artemisinin-based combination therapies available with an efficacy >90% that can effectively treat *P. falciparum*. Similarly, high treatment failures with artesunate-sulfadoxine-pyrimethamine were detected and led to appropriate policy changes in Sudan, Somalia and north-east India. While *P. vivax* resistance to chloroquine has been reported from all WHO regions, chloroquine remains efficacious in most parts of the world. To date, *P. vivax* resistance to artemisinin has not been identified.

Mutations in the *P. falciparum Kelch 13 (PfK13)* BTB/POZ and propeller domain have been shown to be associated with artemisinin partial resistance. In GMS countries, most samples were found to carry *PfK13* mutations. Outside of the GMS, findings of *PfK13* mutations in two countries give special cause for concern. In Guyana, the validated marker C580Y was found in surveys in 2010 and 2017. Similarly, in Rwanda, another validated marker, R561H, was detected for the first time in 2014 and appears to have become more prevalent across the country. There is also evidence suggesting that the R561H mutation may be affecting the clearance rate, although the artemisinin-based combination therapies tested currently remain efficacious. Both mutations emerged independently and did not originate from the GMS.

3.1.4 Environmental surveillance of antimicrobial resistance

Environmental reservoirs are known to contribute to the emergence and spread of AMR, such as wastewater discharges from communities, health facilities, and antimicrobial manufacturing sites and their downstream water bodies. For this reason, both the FAO and WHO GAP-AMR recommend the development of techniques for the environmental surveillance of AMR *(87)*.

Since 2015, WHO has proposed and pilot tested several new environmental surveillance approaches. For example, GLASS is monitoring and assessing the usefulness of the ESBL *E. coli* Tricycle project (Section 2.5) that includes environmental surveillance techniques in its framework to complement the established surveillance of AMU and AMR in bacteria from humans and animals.

In 2020, FAO, OIE and WHO jointly published the "Technical brief on WASH and wastewater management to prevent infections and reduce the spread of AMR" in five languages *(88)*. The brief places evidence and implementation actions on environmental surveillance within the context of evidence and preventive measures on the management of wastewater from communities, health care facilities, plant and animal production, and antimicrobial manufacturing. Based on this technical brief, FAO, OIE and WHO, together with UNEP, will lead awareness-raising and capacity-building in 2021 and beyond to strengthen environmental aspects within AMR national action plans, including aspects of surveillance where appropriate and feasible.

3.2 Regional activities to promote AMR surveillance in common bacterial pathogens

3.2.1 WHO African Region

The WHO Regional Office for Africa continues to support Member States in developing and implementing their AMR national action plans in line with the One Health approach, while also strengthening partnerships with FAO, OIE, UNEP, the African Union Commission, Africa CDC, and other partners for more coordinated and impact-driven AMR strategies in the Region.

To date, 36 countries have finalized their national action plans and 21 have been approved officially by national authorities. Progress on the implementation of AMR national action plans has been documented by the WHO, FAO and OIE using the TrACSS *(10)*. Indeed, the report by the WHO Director-General to the World Health Assembly and by the UN Secretary-General to the UN General Assembly in 2019 was based on the findings of the questionnaire survey. Leveraging on the COVID-19 pandemic, the Regional Office provided remote guidance and training to national focal points from all Member States aiming to reinforce AMR/AMU surveillance, given the additional risks of AMR posed by the increased use and misuse of antimicrobials. IHR joint external evaluations, which also provide information on the status of surveillance of AMR, have been conducted in 46 of the 47 countries in the Region.

The Regional Office also continues to provide technical guidance on GLASS implementation. Eight new countries joined GLASS AMR and/or AMC in 2020 (Algeria, Angola, Burkina Faso, Burundi, Benin, Cameroon, Namibia, Togo) and one in January 2021 (Democratic Republic of the Congo), thus strengthening their national surveillance systems. As of February 2021, 30 of the 47 countries had completed their enrolment. So far, four countries participate in both GLASS AMR and AMC (Benin, Burkina Faso, Côte d'Ivoire, Mali) while South Sudan currently participates only in GLASS AMC. Regional capacity for AMR/AMU surveillance was reinforced with five webinars provided to all Member States. Webinars were organized within the framework of online consultations as a forerunner to the *3rd High Level Technical Consultation and Meeting on Surveillance of Antimicrobial Resistance and Use for Concerted Action (22)*. One of the major outputs expected is an updated roadmap for the coordination and implementation of global surveillance of AMR/AMU and ways of addressing gaps in GLASS.

There has been notable progress in the Mali national surveillance system. This can be evidenced by the recent implementation of a monitoring and evaluation plan, as well as the renovation of the NRL within the framework of a project supported by the Korean International Cooperation Agency (KOICA), in partnership with GLASS, aiming at establishing a national AMR surveillance system and strengthening laboratory capacity. Support is being provided to Togo to implement a project for the mentorship of bacteriology laboratories to promote an improved quality of ASTs performed. Guinea was also supported to review its national quality plan for medical laboratories that will ultimately address issues related to weak AST and enhance AMR surveillance. In addition, successful collaboration with partners and various stakeholders includes the implementation in seven countries (Burkina Faso, Cameroon, Ghana, Madagascar, Nigeria, Zambia, Zimbabwe) of the ESBL *E. coli* Tricycle project (Section 2.5), identified as a simplified and integrated multi-sectoral surveillance system for bacterial resistance in humans, the food chain, and the environment.

The Regional Office co-facilitated the *Regional stakeholders' workshop on external quality assurance for antimicrobial resistance* organized by Africa CDC and the African Society for Laboratory Medicine on 9-10 February 2020, in Johannesburg, South Africa. This was an engagement and consultation workshop for key stakeholders on Fleming Fund EQA regional grant objectives, strategic approaches, activities and expected outcomes. It is expected that the comparative advantages highlighted by WHO representatives at the meeting will support joint efforts to build regional capacity on AMR diagnostics and enhance the quality and coverage of EQA. In addition, the Regional Office initiated a collaboration with the Institut Pasteur d' Alger, Algeria, to build the laboratory capacity of Member States for enhanced AMR surveillance. Of note, 49 laboratories in 28 countries are currently participating in WHO EQA for AST.

The Regional Office has trained national professionals from 35 countries in monitoring AMC. So far, 10 countries have established national AMC surveillance systems and 15 countries have carried out PPS-AMU (Section 2.7) in hospitals to inform policy and appropriate stewardship interventions. In the 2018–2019 TrACSS self-assessment report, 19% of responding countries reported a national monitoring system for the consumption and rational use of antimicrobials in human health, and 74% reported laws or regulations on the prescription and sale of antimicrobials for human use.

Robust AMR implementation, including AMR surveillance at the regional and country level, demands strong buy-in across all sectors. To enable and support such implementation, AMR awareness and advocacy strategies continue to be important to ensure that politicians, policy-makers, professionals, civil society actors, and the society at large understand why it is critically important to address AMR, including the vital role that AMR surveillance plays in these efforts. To ensure a cohesive and impact-driven AMR awareness and advocacy, the Region has developed an AMR campaign website, which gives Member States and stakeholders the opportunity to download context-specific materials and tools, including videos and personal stories of those impacted by AMR in the Region. In addition, the Region has been collaborating since 2019 with the Tripartite members (FAO, OIE, WHO, as well as UNEP), the African Union, Africa CDC, and the African Union Inter-African Bureau for Animal Resources to jointly commemorate World Antimicrobial Awareness Week (WAAW). In this regard, despite the challenges posed by COVID-19, the first joint virtual WAAW was organized and attended by the heads of all the regional agencies (Africa CDC, African Union Inter-African Bureau for Animal Resources, FAO, OIE, UNEP, including the WHO Regional Offices for the African Region and the Eastern Mediterranean). It featured presentations on AMR surveillance in the human health sector from Tunisia, AMR on the environment from Kenya, and AMR in the veterinary sector from Lesotho. The virtual WAAW event was attended by over 1200 participants from all over the Region with the Directors and Regional Directors of the respective institutions renewing their commitment to unite against AMR in the African Region.

3.2.2 Region of the Americas

The WHO Regional Office for the Americas/PAHO supports AMR surveillance, prevention and control in the Region through its AMR special programme. Forging new and expanding existing initiatives and platforms, the programme works with the countries and various partners to ensure the availability of standardized, quality AMR laboratory and epidemiological surveillance data, improve our understanding of the epidemiology and impact of AMR in the Region, inform patient care, and guide policies and interventions to combat AMR at the local, national, regional and global level.

In 2020, building on the well-established ReLAVRA network, the Regional Office launched the "Protocol for enhanced isolate level AMR surveillance in the Americas; primary phase: bloodstream infection" *(89)*. Its main objective is to improve our understanding of the scope and effects of AMR in various populations by integrating individual laboratory and epidemiological surveillance data. To date, 13 countries have taken part in the early implementation phase of the protocol (Argentina, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Peru, Uruguay, Paraguay, Mexico, Trinidad and Tobago, Belize). The approach builds on the ReLAVRA methodology, but also aligns with the GLASS methodology, thus enabling countries to participate in GLASS. The Regional Office has also continued updating its "ReLAVRA AMR dashboard" that aims to facilitate online access to standardized, validated data for decision-makers, health professionals and the general public *(90)*.

In several countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Guatemala, Mexico, Panama, Paraguay, Peru, Uruguay, Venezuela), the enhanced surveillance protocol has also included surveillance of AMR in *Candida* spp., thanks to the collaboration of the Regional Office and WHO Collaborating Centres (WHO Collaborating Centre on Antimicrobial Resistance Surveillance [ARG-43], at the ANLIS-Malbran Institute, Argentina, and the WHO Collaborating Centre for Surveillance, Epidemiology and Control of Foodborne Diseases and other Enteric Pathogens [USA-417] at US CDC). The surveillance of AMR in *Candida* spp. aligns with the "GLASS Early implementation protocol for inclusion of *Candida* spp." (Section 2.4). The WHO Collaborating Center on Antimicrobial Resistance Surveillance (ARG-43) has provided support in strengthening AMR diagnosis and developed the first EQA programme for fungal disease diagnosis in Latin America and the Caribbean, which has enrolled 10 countries to date. To further strengthen laboratory capacity for the diagnosis of fungal infections, the Regional Office developed a three-month course and worked with countries using WHONET to integrate both bacterial and fungal AMR isolate-level data to facilitate data collection and avoid duplication of efforts. To date, two countries have shared bacterial data and three countries have provided fungal data as part of this enhanced surveillance. Another seven countries are expected to share data during 2021. Despite the major challenges that the COVID-19 pandemic has imposed on health systems across the Region and consequently on AMR surveillance, it is important to highlight that countries were able to maintain their capacity to detect and rapidly alert to any AMR threats of public health importance, thus prompting a timely and effective response.

In the context of the European Union-funded "Working together to combat AMR" project implemented by the Tripartite alliance in seven Latin American countries, the Regional Office has held a series of 10 online training sessions on the role of molecular biology in integrated AMR surveillance under the One Health approach. The sessions introduced the various components of integrated surveillance, current phenotypic and molecular analysis techniques, and the importance of public-private partnerships in the prevention of AMR. Success stories from the European Region were shared. As an output from the sessions, participating countries designed pilot projects for integrated AMR surveillance that will be implemented during 2021.

During 2020, the Regional Office also developed training and tools to strengthen antimicrobial stewardship programmes across the Region and continued to support Member States in updating their national essential medicines lists, including the evidence-based selection of antimicrobials and incorporation of the AWaRe classification. A specific essential medicines list was developed for the treatment of critical patients with a suspected or confirmed diagnosis of COVID-19.

From 28 November to 9 December 2020, the Regional Office, in collaboration with WHO headquarters, held a regional consultation over four online sessions within the framework of online consultations in preparation for the *3rd High Level Technical Consultation and Meeting on Surveillance of Antimicrobial Resistance and Use for Concerted Action*. The online consultation collected feedback and insights for implementation on the latest GLASS documents, including GLASS 2.0, the inclusion of *Candida* spp. in GLASS, the use of molecular technologies in AMR surveillance, the estimation of AMR attributable mortality, the monitoring of AMC at the hospital level, and the integration of surveillance in a One Health approach. Over 100 participants connected to each online session, representing a diverse audience (microbiologists, epidemiologists, clinicians, public health professionals from ministries of health and partner institutions) from 21 of the 28 countries in the Region. In addition to gathering valuable feedback on the various GLASS documents, the fruitful discussions of the sessions, together with the results of short surveys and polls administered, contributed to developing a road map to continue strengthening AMR surveillance in the Region and define the work agenda for technical cooperation to countries. Participants emphasized the need to adapt the road map for GLASS implementation to the wide range of resources and capacities of countries. The consultation also confirmed countries' interest in generating burden of disease estimates and, more specifically, in a regional adaptation of the proposed "GLASS method for estimating attributable mortality of AMR bloodstream infections" (Section 2.8). The adaptation would take into account the AMR epidemiology in Latin America and the Caribbean, as well as resources and infrastructures in place. Based on this feedback, the Regional Office will be developing a strategy to support these countries in measuring the AMR burden, starting with working with experts on a regional adaptation of the WHO protocol, with an emphasis on implementation considerations. The protocol is expected to be piloted in at least one country during 2021-2022.

3.2.3 Eastern Mediterranean Region

The WHO Regional Office for the Eastern Mediterranean continues to establish and enhance national AMR surveillance systems to support the generation of good quality AMR data for countries to design and implement national AMR prevention strategies and contain AMR. Since early 2020, the COVID-19 pandemic has heavily impacted on the implementation of AMR surveillance in the Region and initially forced the AMR and other health programmes to take second place during the first half of the year. Despite the challenges, AMR was successfully back on the political agenda of countries due to the vigorous efforts of all concerned national stakeholders and WHO. During 2020, in addition to the 18 countries enrolled in previous years, three further countries (Djibouti, Morocco, Somalia) enrolled in GLASS, which now represents 95% (21/22) of countries in the Region. By the end of 2020, 18 of 22 countries (82%) reported to GLASS a total of 127 206 isolates, representing a 37% increase compared to the previous year.

In Jordan, AMR surveillance activities have benefited from the support provided by KOICA since early 2018. The reporting of data to the national coordinating centre is conducted in 15 sentinel hospitals, representing 38.5% of tertiary healthcare facilities. To ensure the reporting of good quality AMR data, the Ministry of Health assigned a national surveillance monitoring and evaluation team to visit the sentinel sites on a regular basis and to provide technical assistance. In November 2020, Jordan also successfully released their first national AMR surveillance report during the WAAW. Of note, with data generated by the recently established national surveillance system, Jordan is the first LMIC in the Region to develop a national antimicrobial stewardship policy where the Ministry of Health established the governance structure at both the national and health care facility levels, and developed national clinical guidelines for priority infections.

Pakistan is one of the priority countries in the region for AMR surveillance. In 2020, the National Institute of Health successfully launched a national AMR surveillance plan and expanded the number of sentinel hospitals from eight in 2019 to 20 sites in 2020, representing various geographical areas, as well as different public and university hospitals. All surveillance sites regularly report AMR data to the national coordinating centre at the National Institute of Health, which enabled Pakistan to release its first national AMR surveillance report at the end of 2020. In addition, Pakistan completed a prevalence survey to measure physician prescribing practices among hospitalized patients in 14 public and private hospitals. These data will be utilized together with AMR data to design and implement tailored prevention activities for AMR.

In 2020, the Ministry of Health in Tunisia officially established the national coordinating centre and NRL for AMR surveillance and was successfully able to enrol 11 surveillance sites to the national AMR surveillance system, accounting for 22.1% of the total hospital beds in the country. These sites were able to provide AMR data to the national coordinating centre.

The development of IT solutions to support the implementation of national AMR surveillance has been a priority for the Regional Office. To achieve this, the Office has developed a website application for Jordan and Tunisia, hosted on Ministry of Health servers, to automatically merge and compile the reported AMR data shared by sentinel sites into a centralized database. This application will be upgraded over time to provide an automated timely analysis of national AMR data.

The Regional Office's efforts to help enhance the microbiology laboratory capacities of selected countries continued in 2020. Assessment of the regional NRLs was conducted in 21 countries to generate baseline information on laboratory capacities and to develop targeted improvement plans. Onsite laboratory assessment visits were also conducted in Morocco and Sudan to prioritize and address gaps in detecting and reporting AMR. Virtual meetings were regularly conducted with several countries to monitor laboratory progress and provide needed technical support (Iran, Jordan, Libya, Palestine, Syria, Tunisia, Yemen). An onsite microbiology workshop was conducted in Egypt to reinforce the role and functions of the NRL and to enhance its capacity to coordinate and support the network of national laboratories participating in surveillance. To ensure that NRLs perform properly, the Regional Office has equipped priority laboratories with biosafety cabinets, incubators, and essential and specialized quality control strains.

Five countries (Iran, Jordan, Morocco, Pakistan, Sudan, Iran) in the Region are piloting the One Health Tricycle project (Section 2.5). Pakistan and Jordan have terminated the project and both are now conducting molecular characterization in the form of whole genome sequencing with the support of WHO Collaborating Centres. Morocco started the collection phase for the three work packages in August 2020. Iran and Sudan needed to be supported with additional essential laboratory supplies and will start in 2021.

In 2020, a virtual regional meeting was held on the GLASS-AMC module (Section 2.1), specifically covering national and hospital AMC surveillance protocols. In addition, country-specific, virtual national AMC training workshops were conducted for Iraq and Egypt to monitor the AMC data collection process. Of note, important reports were launched by Pakistan and Jordan on national AMC. In Pakistan, two reports on "Strengthening technical skills for measuring antimicrobial consumption in Pakistan" and "Institutional and landscape analysis for estimating antimicrobial consumption in Pakistan" were published in 2020. In Jordan, an analysis report for 2017 and 2018 data on national surveillance of AMC has been formally developed. In preparation for the *3rd High Level Technical Consultation and Meeting on Surveillance of Antimicrobial Resistance and Use for Concerted Action* in April 2021, online consultations from October 2020 to February 2021 were held to obtain feedback on five GLASS documents and inform future directions for GLASS development.

3.2.4 European Region

Surveillance data on health care-associated infections, AMC and AMR have been collected for over two decades in countries of the European Union and the European Economic Area through networks initially funded by the European Commission. Data collected in these networks by ECDC have provided trends and signal priorities to policy-makers *(13, 28)*. The WHO Regional Office for Europe, together with partner institutions[10], established the network for the monitoring of AMC and the CAESAR network for AMR surveillance with the goal to enable and strengthen surveillance systems throughout the Region. Surveillance has been a cornerstone of the regional response to AMR since the launch of the 2011 European Strategic Action Plan on Antibiotic Resistance, which continues to guide the regional implementation effort and is set to be renewed in 2021.

Since its establishment in 2011, the 19 member countries and areas of the WHO Europe AMC network have been collecting AMC data annually. The Regional Office supports the network by building capacity for data collection, analysis, dissemination of findings, and a further intervention to improve the use of antibiotics in practice. The third report of the WHO Europe AMC network included an analysis of AMC data for 2014–2018, with all countries and areas included in the report. The analyses applied the changes to DDDs implemented in 2019 and the update of the WHO AWaRe classification of antibiotics in 2019, and also assessed concordance with the WHO global/national target, which specifies a country-level target of at least 60% of total antibiotic consumption from medicines in the Access group. The WHO AMC network has an active collaboration with ESAC-Net, coordinated by the ECDC, which collates and analyses data on antibiotic consumption from countries in the European Union and European Economic Area. In 2020, the first joint publication of the ECDC and WHO Regional Office for Europe using AMC data for 2014–2018 was prepared and is planned to be published in 2021.

In addition to the national surveillance of AMC, seven member countries of the AMC network conducted a study to investigate patterns of antimicrobials supplied in community pharmacies in Eastern Europe and Central Asia following the COVID-19 pandemic. Data were collected over a one-week period from community pharmacies located in six different regions within a country. The study will summarize antimicrobials supplied, reason for use, and the relative use of agents from the WHO AWaRe classification.

The CAESAR network, established in 2012, provides technical assistance to improve the quality of laboratory test results and the collection, management, analysis, and reporting of data on AMR. Currently, 19 countries and areas are engaged in the network, of which 12 submitted AMR surveillance data from isolates obtained in 2019 for the CAESAR annual report published in November 2020 (Armenia, Belarus, Bosnia and Herzegovina, Georgia, Kosovo[11], Montenegro, North Macedonia, the Republic of Moldova, the Russian Federation, Serbia, Switzerland, Turkey, Ukraine). Regional network meetings are held annually since 2013 and national network meetings are also organized periodically to foster network engagement, discussion of surveillance data, the results of the annual CAESAR EQAs, and priorities for further technical support.

One challenge that remains year after year is the limited routine AST performed in several countries of the CAESAR network due to the underutilization of microbiological diagnostics in clinical practice. The proof-of-principle AMR routine diagnostics surveillance project was established in 2015, with the objective to stimulate the collection of blood cultures from patients with suspected BSIs. Currently proof-of-principle projects are ongoing in Tajikistan and Uzbekistan, including other countries beyond the European Region. Work is underway to expand the scope of these projects to a more comprehensive approach for improving health care capacities and patient treatment. This can be achieved by including elements of antimicrobial stewardship, infection prevention and control, surveys of health care-associated infections, and by tapping into behavioural insight methodologies. In addition, country support will focus not only on data collection, but also on supporting the use of data and information to inform policy interventions and measure their effect. First steps in this regard were taken in Turkey in 2020, with plans to expand to more countries in the Region.

Currently, 25 countries and areas in the European Region are enrolled in GLASS, a number which the Regional Office hopes to further expand. The year 2020 meant setbacks for many initiatives at the country level due to the challenges posed by the COVID-19 pandemic on health care professionals, systems, and infrastructures. The real impact of the pandemic will only be felt in 2021 when surveillance data for 2020 will be collected and analysed. On a positive note, participation in the EQA exercise 2020 remained steady, compared to previous years. In 2020, the CAESAR network was not able to hold a face-to-face meeting, but organized a series of technical webinars instead, as well as GLASS virtual consultations[12], which enjoyed broad Member State participation and provided an opportunity to discuss future directions and initiatives for GLASS.

10 Most notably, for AMC, the University of Antwerp, Belgium; and for CAESAR, the WHO Collaborating Centre for Antimicrobial Resistance Epidemiology and Surveillance (NET-89) at the Dutch National Institute for Public Health and the Environment and the European Society of Clinical Microbiology and Infectious Diseases.

11 All references to Kosovo in this document should be understood to be in the context of United Nations Security Council resolution 1244 (1999).

12 Online consultation held in preparation for the *3rd High Level Technical Consultation and Meeting on Surveillance of Antimicrobial Resistance and Use for Concerted Action* held in April 2021.

3.2.5 South-East Asia Region

Recognizing the serious threat to global and regional health, the Regional Director of the South-East Asia Region made AMR a flagship priority in 2014, with a focus on clear deliverables at both regional and country levels. The Regional Office has continuously provided governance oversight for a better implementation of AMR national action plans to ensure an increasingly integrated multi-sectoral One Health approach to AMR.

The Region has continued to strengthen high-level political commitment, deliverable implementation, and plausible evaluation. In collaboration with country offices, it continues to; (i) provide technical support needed in the areas of surveillance, laboratory capacity, human resources, and research and development; (ii) provide information and facilitate support in AMR awareness and antimicrobial stewardship; (iii) develop and implement a strategy on One Health for the Region, aligned with efforts already underway in several countries; and (iv) support global and regional situation analyses to monitor and evaluate One Health AMR programme implementation.

In 2020, the Asia-Pacific Strategy on Emerging Diseases meeting reiterated the importance of AMR as an emerging infectious disease threat and the need for a One Health approach to combat it. In this regard, the Regional Tripartite (FAO, OIE, WHO) identified the importance of close coordination and communication between human, animal, plant, aquaculture, and environmental sectors to address rapidly increasing AMR, as well as zoonotic diseases and food safety threats, and signed a *Joint Statement of Intent to Coordinate* pledging to work with Members and strengthen coordinated efforts to fight these health threats. They committed to establish and support a Tripartite One Health Coordination Group for Asia and the Pacific to consolidate the multi-sectoral work carried out over many years in the Region, including the eight regional workshops on multi-sectoral collaboration at the animal-human-ecosystems interface. A close collaboration with UNEP to include environmental aspects has also been established.

To strengthen antimicrobial stewardship and promote AMR awareness, the Regional Office has established a pool of regional consultants to support the development of national policies and guidelines on antimicrobial stewardship, including the adoption of the antimicrobial AWaRe categorization in the national essential medicines list (national formulary) *(31)*. Bangladesh, Bhutan, Indonesia, Maldives, and Nepal have included or are in the process of adopting the AWaRe categorization. Furthermore, to promote antimicrobial supply chain regulation, the Regional Office has institutionalized AMR as a core agenda item for meetings of the steering group of the South-East Asia Regulatory Network. Of note, since the first edition of the WAAW on 16–22 November 2015, the Regional Office has been very active and has rolled out many events every year to promote AMR awareness.

Supported by WHO headquarters, the Regional Office has provided technical assistance for the implementation of GLASS in Member States. By April 2021, all Member States in the Region had enrolled in GLASS-AMR and had entered information from national surveillance systems in GLASS. Regional EQA was conducted in NRLs in 50% of surveillance sites in the Maldives and 100% of those in Bangladesh, Bhutan, India, Indonesia, Myanmar, Nepal, Sri Lanka and Thailand. Innovative models of integrated One Health AMR surveillance have been piloted in Indonesia (and are ready to start in India and Nepal), including the ESBL *E. coli* Tricycle project. Indonesia, Maldives, Nepal, and Timor-Leste are now formally enrolled in GLASS-AMC. A call to join the AMC component of GLASS was sent to all countries in June 2020. As AMC surveillance needs to be scaled up to enrol all 11 countries in the Region in GLASS-AMC, a pool of regional consultants has been made available to support national AMC surveillance. Technical support has been extended to strategic small TDR (Special Programme for Research and Training in Tropical Diseases) grants for research studies on drivers and determinants of AMR in Member States, with the aim of generating evidence for policy action.

Monitoring and evaluation are an important function in AMR governance. The Regional Office has supported the TrACSS in 2016-2017, 2017-2018 and 2019-2020 and has prepared a report documenting progress over these three periods *(10)*. Positive signs have been observed with all countries having AMR national action plans with improving linkages to HIV, tuberculosis, malaria and neglected tropical disease programmes. In addition, most countries have multi-sectoral AMR working groups (although only one-half are functional) and national AMR/AMU surveillance systems, including in the animal sector. However, gaps remain in multi-sectoral engagement, data analysis and systemic capacity, as well as lack of resources for the implementation of AMR national action plans across sectors. The Regional Office has also developed and is leading a 3rd Tripartite (including UNEP for environmental aspects) regional situational analysis, specifically looking at progress in the implementation of AMR national action plans.

3.2.6 Western Pacific Region

In line with the 2019 "Framework for Accelerating Action to Fight Antimicrobial Resistance in the Western Pacific Region", all Member States in the Region have accelerated the development of policies, enhanced national action plans, and strengthened systems to combat AMR in varying ways. Global and regional mechanisms have worked in parallel with WHO support to foster collaboration and action to fight AMR across countries. The set of operational shifts and new ways of working under the Framework have led to substantial progress on AMR in the Region.

In the Region, WHO has leveraged mechanisms and systems developed under the "Asia-Pacific Strategy for Emerging Diseases" and other initiatives to bring together work to combat AMR through strengthened clinical management and infection prevention and control in order to minimize transmission risks during health care. As part of response and preparedness efforts for outbreaks – such as COVID-19 and measles – WHO supports Member States in strengthening infection prevention and control measures, implementing antimicrobial and diagnostic stewardship, and building laboratory capacity. Furthermore, capacity-building and guidance is being developed on AMR surveillance and the AMR outbreak response. These investments help mitigate outbreaks and strengthen health systems to better address AMR and other health challenges in the future.

The WHO WPRACSS was launched in 2020 and aims to increase multi-stakeholder accountability and strengthen stewardship of antimicrobials to improve health outcomes. The system captures and synthesizes information on consumption across sectors and countries in the Western Pacific Region. Thirteen countries and areas are already participating as WHO works to enable others to improve AMC monitoring. The first report of AMC in the Region was launched in early 2021 to report consumption data from 2018 from seven countries and areas. The early implementation phase of WPRACSS highlights significant differences in the consumption of antimicrobials at national level. It is encouraging to note that most countries predominantly use antimicrobials of the Access category (Annex 1). Data collected through WPRACSS will be used by countries to improve antimicrobial stewardship and to feed into the GLASS-AMC module (Section 2.1).

As of early 2021, nine counties have enrolled in GLASS. The Regional Office will also support AMR surveillance by establishing a network of AMR reference laboratories and formalizing a regional network of institutions to support capacity-building on AMR surveillance and outbreak response, in addition to provision of broader support for health systems, including stewardship, AMC monitoring and infection prevention and control.


SECTION
04

4. Country, territory and area profiles

4.1 Country, territories and areas profiles

The profiles summarize surveillance activities participation for AMR, AMC, HIV infection, TB, malaria, and focused surveillance (Tricycle and EGASP). Indicators were selected to describe the structure of the surveillance system in each country. The population estimates given in each country profile are from the Population Division of the UN Department of Economic and Social Affairs in 2019 or countries national censuses, the year of AMR data collection *(91)*.

Afghanistan

Population 38.04 million

With technical support of the WHO country office, Afghanistan initiated the AMR control program. The country has made some progress which need further investment for its institutionalization.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

1
laboratory participating to the national surveillance system[a]

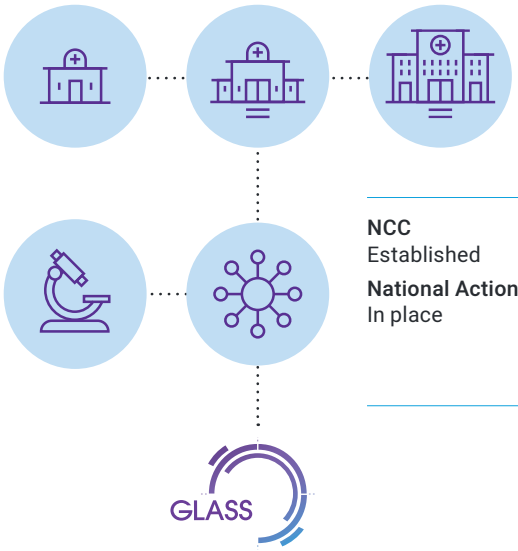
1 laboratory performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
Number of surveillance sites providing data to GLASS not reported



NCC
Established

National Action Plan
In place

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

a The identification of the total number of participating laboratories submitting data to GLASS was not possible due to the set-up of the National surveillance system

Argentina

Population 44.78 million

The "National Antimicrobial Resistance Surveillance Network: WHONET-Argentina" is coordinated by the Antimicrobial Agents Division of the National Institute of Infectious Diseases-ANLIS "Dr. Carlos G. Malbrán", Ministry of Health. Argentina is implementing the AMR National Action Plan published in 2015. The country participates in ReLAVRA since 2000 and has been enrolled in GLASS in April 2019.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

91 surveillance sites participating to the national surveillance system

91 in-out patient facilities

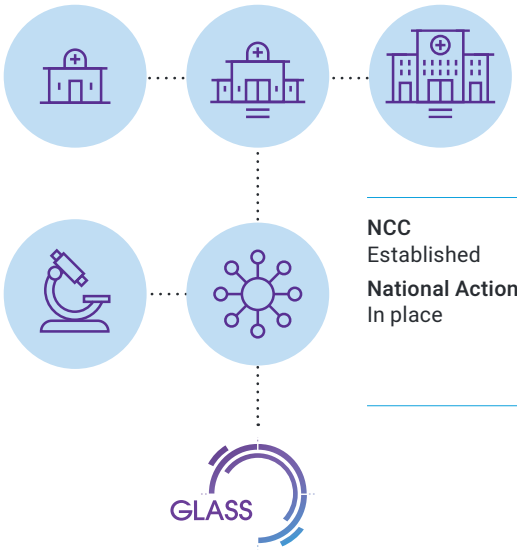
91 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
70 surveillance sites providing data to GLASS (70 in-out patient facilities)



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2014
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2005
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Australia

Population 25.5 million

Australia enrolled in the GLASS in April 2019, and released its second national AMR strategy, Australia's National Antimicrobial Resistance Strategy: 2020 & Beyond, in March 2020. Australia will continue to develop its One Health approach to surveillance by building on its existing antimicrobial consumption (AMC) and resistance (AMR) surveillance system following further assessment across the animal, food and environment sectors.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

41
surveillance sites participating to the national surveillance system

41
in-outpatient facilities

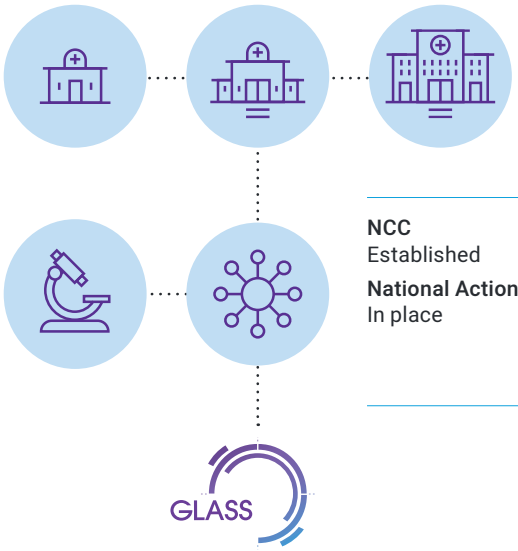
34 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI/Others

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	22
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Austria

Population 8.96 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

119
surveillance sites participating to the national surveillance system

119
in-out patient facilities

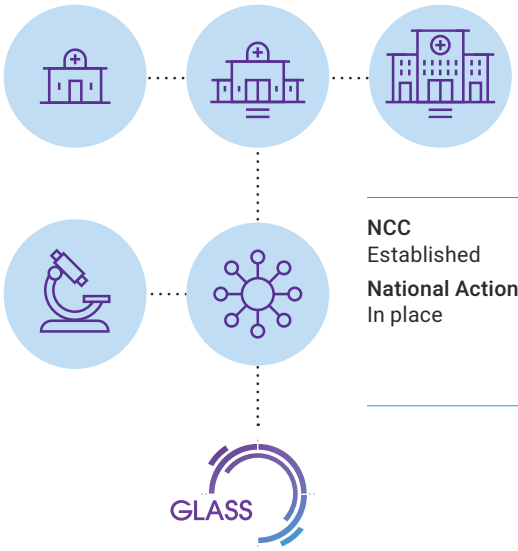
38 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2015
Number of data points[2]	17
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)[a]

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

a Austria makes no warranties, express or implied, regarding the content, presentation, appearance, completeness of the data reported by GLASS

Bahrain

Population 1.64 million

Bahrain has a National Action Plan on AMR approved in 2018. 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.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

38 surveillance sites participating to the national surveillance system

10 hospitals

28 outpatient facilities

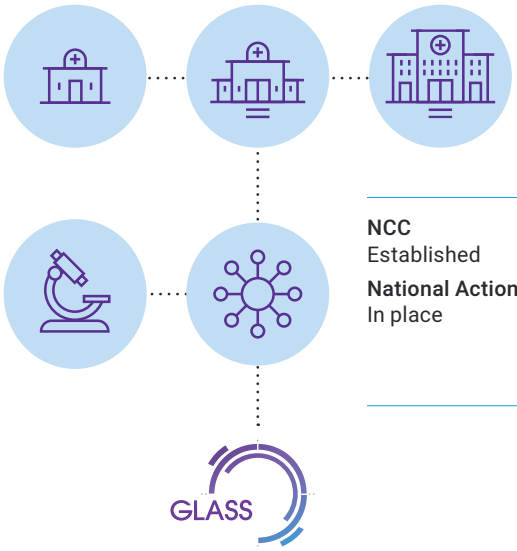
6 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	7
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Bangladesh

Population 163.05 million

The current AMR surveillance system is based on case-based surveillance of clinical syndromes, which will be complemented by Laboratory based surveillance in a short time.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

9
surveillance sites participating to the national surveillance system

9
in-out patient facilities

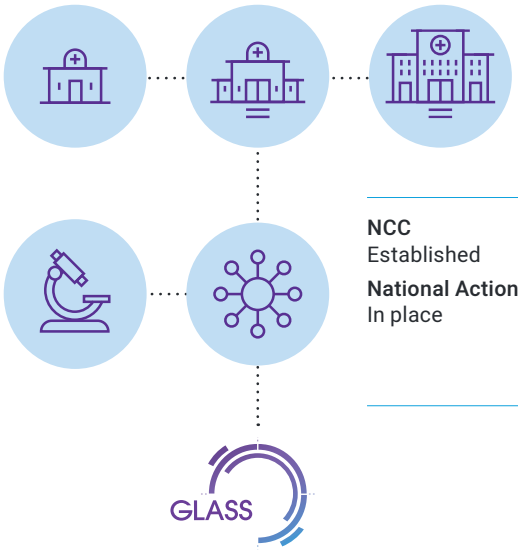
8 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Bhutan

Population 0.76 million

The AMR system in Bhutan follows the National Action Plan for AMR (NAP–2018–2023).

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

4 surveillance sites participating to the national surveillance system

4 in-out patient facilities

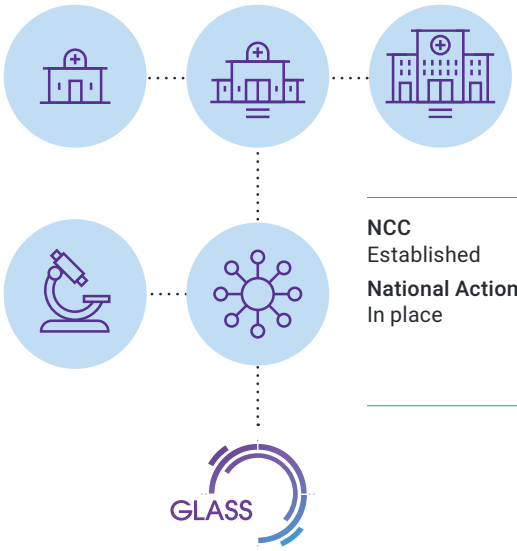
4 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
3 surveillance sites providing data to GLASS
(1 hospital)
(1 outpatient facility)
(1 in-out patient facility)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	4
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Bosnia and Herzegovina

Population 3.5 million

Bosnia and Herzegovina is participating in the CAESAR network since 2015. AMR surveillance activities are conducted by two networks; one in the Federation of Bosnia and Herzegovina and one in Republika Srpska. The estimated coverage of the population is 75% in the Federation of Bosnia and Herzegovina and 85% in Republika Srpska.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

12
laboratories participating to the national surveillance system[a]

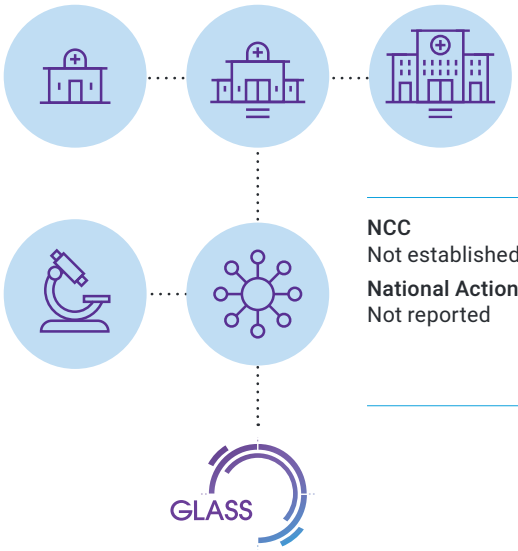
12 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national participating laboratories reported to GLASS



NCC
Not established

National Action Plan
Not reported

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	17
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

a 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

Brazil

Population 211.05 million

The surveillance system will be expanding to include all regions in the country.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

17 surveillance sites participating to the national surveillance system

- **5** hospitals
- **6** outpatient facilities
- **6** in-out patient facilities

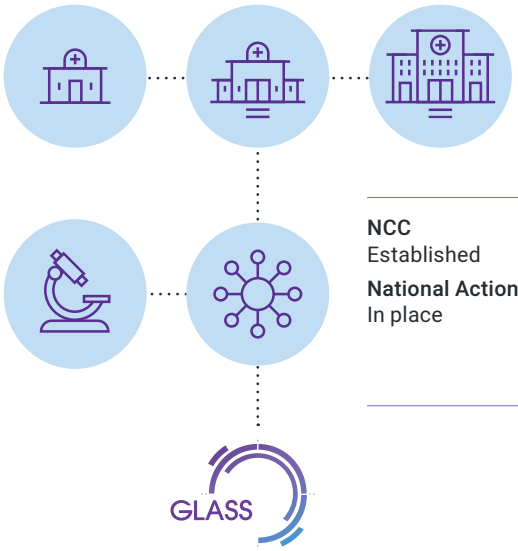
6 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2014
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Subnational
Year of most recent activity	2008
Number of data points[2]	2
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Brunei Darussalam

Population 0.43 million

In December 2019, the Ministry of Health and Ministry of Primary Resources and Tourism have jointly endorsed the Brunei Darussalam Antimicrobial Resistance National Action Plan and enrolled for GLASS.

With that, the National Clinical Microbiology Reference Laboratory for AMR GLASS pathogens has been identified as the only data reporting site focusing initially on the Brunei's largest hospital, Raja Isteri Pengiran Anak Saleha Hospital for the 2019 data call.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

9 surveillance sites participating to the national surveillance system

4 hospitals

5 in-out patient facilities

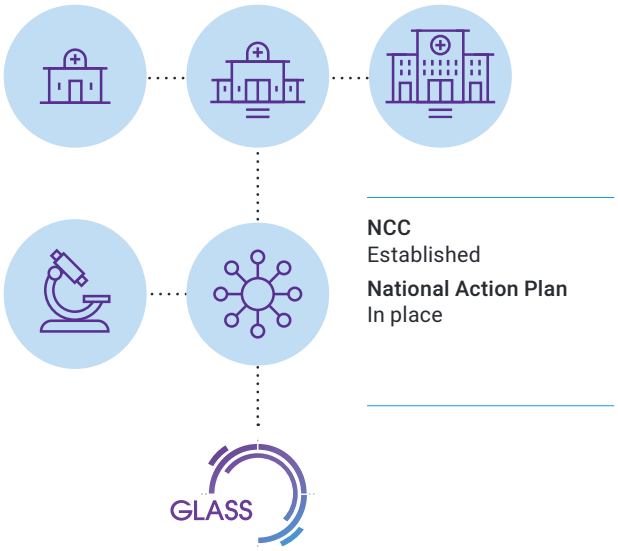
1 laboratory performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
1 surveillance site providing data to GLASS (1 hospital)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	11
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Burundi

Population 11.53 million

During 2020, the capacity of surveillance sites to provide data was investigated in order to report to GLASS. The country is expected to be reporting AMR data in the near future.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

14 surveillance sites participating to the national surveillance system

- **4** hospitals
- **3** outpatient facilities
- **7** in-out patient facilities

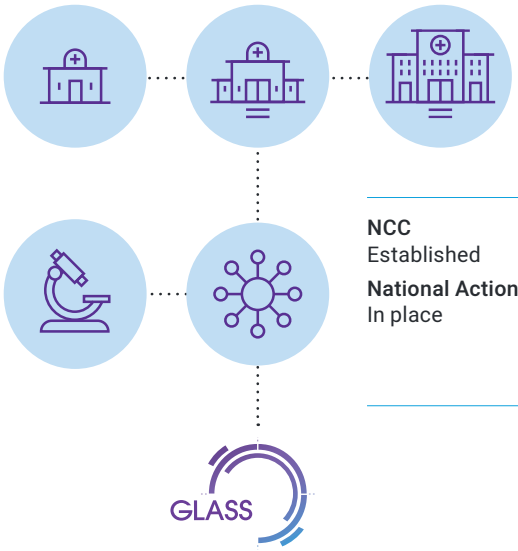
Number of laboratories performing AST not reported
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

Cambodia

Population 16.49 million

The Cambodian Ministry of Health endorsed and launched the Laboratory-Based Antimicrobial Sentinel Surveillance Standard Operation Procedure (SOP) in November 2017. One of the priorities for 2021 is to start analyzing the surveillance data and produce a quarterly AMR surveillance bulletin and to use AMR data for improving infection control and rational use of antibiotics in the hospitals.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	✓

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

8 surveillance sites participating to the national surveillance system

8 hospitals

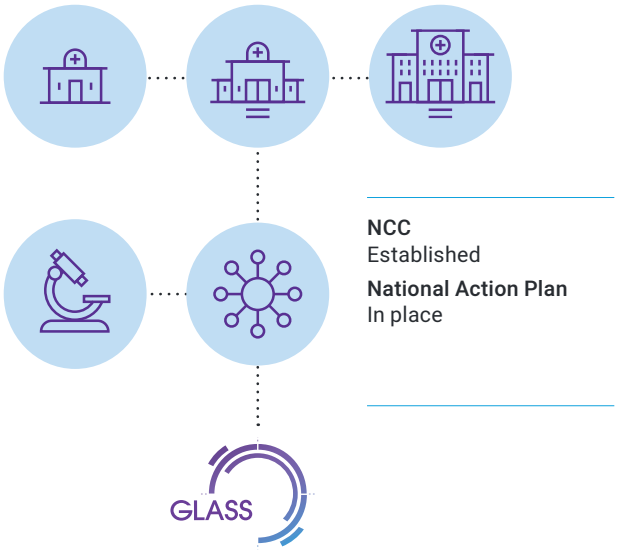
8 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	3
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Canada

Population 37.41 million

The Canadian Antimicrobial Resistance Surveillance System (CARSS) is Canada's national focal point for surveillance of AMR and antimicrobial use. It integrates surveillance data from nine surveillance systems and laboratory reference services operated by the Public Health Agency of Canada and partners. The Federal Action Plan on AMR and Use in Canada was published in 2015.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

73 surveillance sites participating to the national surveillance system

73 hospitals

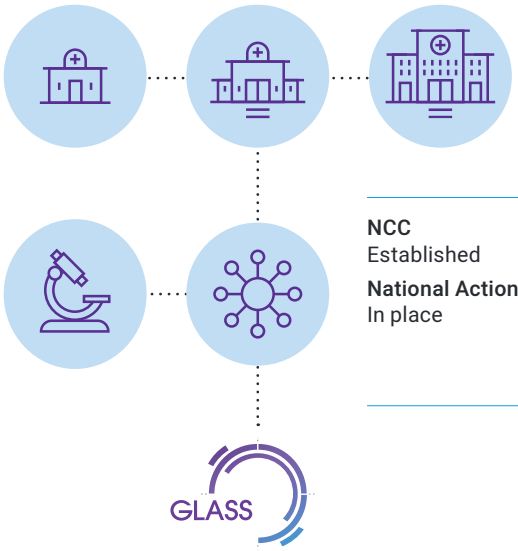
73 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2015
Number of data points[2]	22
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Côte d'Ivoire

Population 25.72 million

Different AMR activities are ongoing in the country. The establishment of the Multi-sectional Technical Committees and the GMC (multisectoral coordination group) in accordance with the strategic objectives of the national action plan is ongoing.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

52 surveillance sites participating to the national surveillance system

29 hospitals

10 outpatient facilities

13 in-out patient facilities

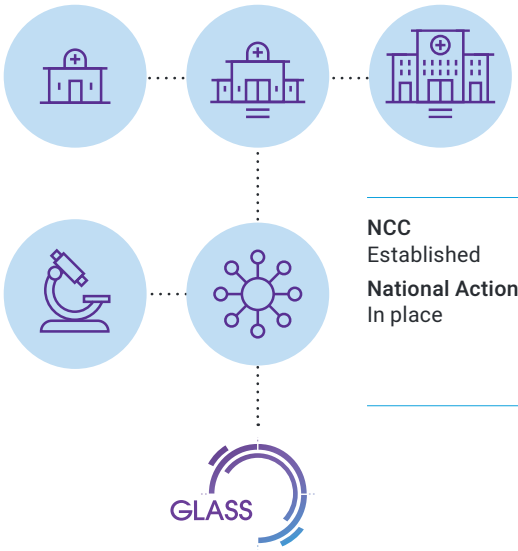
23 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2017
Number of data points[2]	3
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Croatia

Population 4.13 million

Croatia established the Croatian Committee for Antibiotic Resistance Surveillance (CCARS) in 1996 and today the network gathers 35 microbiological laboratories and covers > 90% of Croatian population. The CCARS closely collaborates with the Reference Center for Antibiotic Resistance Surveillance that provides laboratory support for retesting alert organisms and conducting EQA.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

37 surveillance sites participating to the national surveillance system

13 hospitals

8 outpatient facilities

16 in-out patient facilities

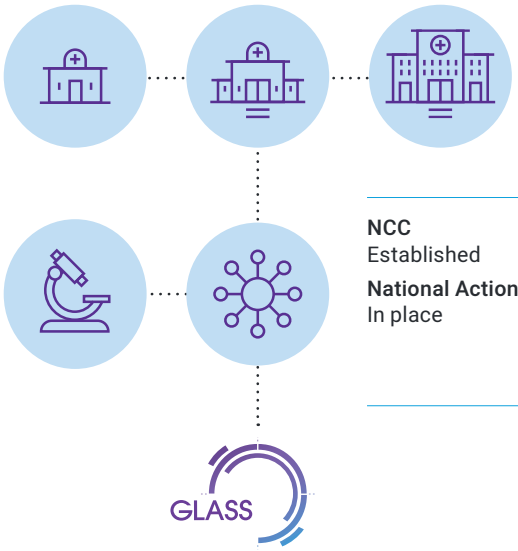
35 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	14
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Czechia

Population 10.69 million

Data on resistance in the Czechia are provided by the National Reference Laboratory (NRL) for antibiotics at the National Institute of Public Health (SZÚ). The NRL cooperates with the working group for monitoring (antibiotic) resistance (PSMR) which has acquired representatives of more than 50 microbiological laboratories, with catchment area that covers approximately 80% of the population.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

70
surveillance sites participating to the national surveillance system

70
hospitals

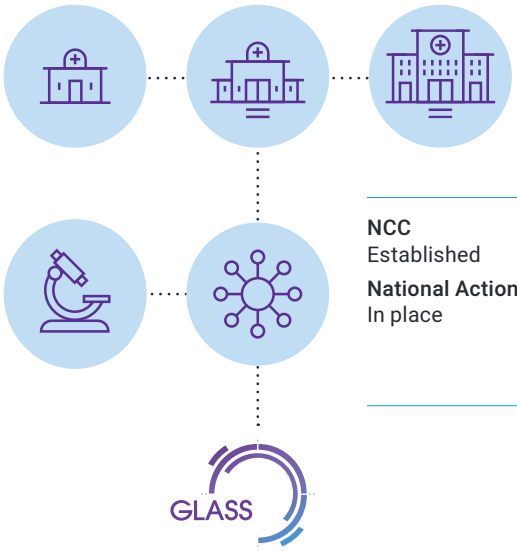
60 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	20
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Egypt

Population 100.39 million

Data submitted to the GLASS was extracted from the national HAI & AMR surveillance implemented in the intensive care units in 39 hospitals in Egypt.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

39
surveillance sites participating to the national surveillance system

39
hospitals

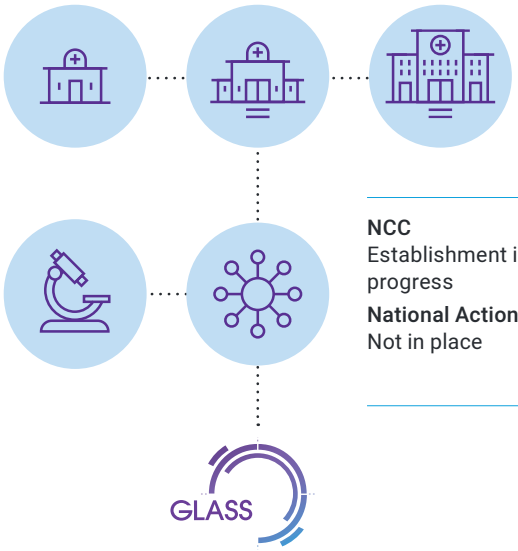
39 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
Not in place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	4
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Ethiopia

Population 112.08 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

9 surveillance sites participating to the national surveillance system

8 hospitals

1 outpatient facilities

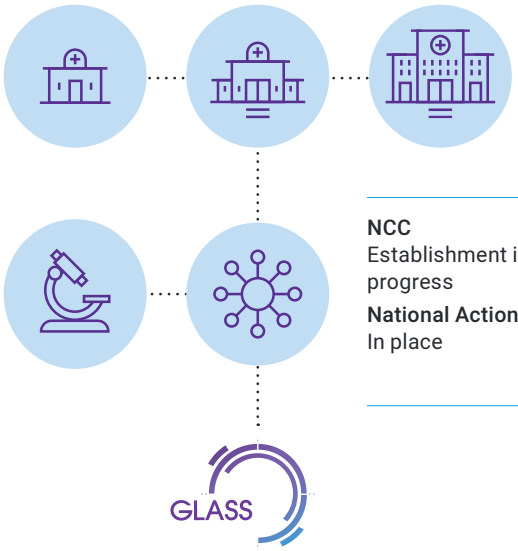
9 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	3
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Finland

Population 5.53 million

Both the public and animal health sectors have well-established AMR surveillance and reporting systems. All clinical microbiology laboratories including private laboratories are participating in surveillance. Results are published yearly in the Finres report.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

24
laboratories participating to the national surveillance system[a]

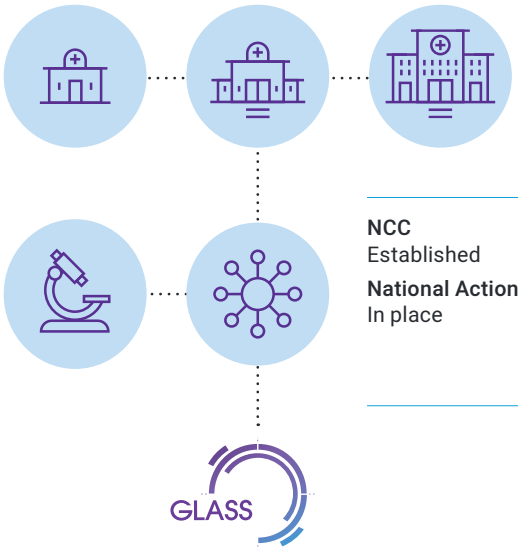
23 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
22 laboratories providing data to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	22
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

a 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

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

France

Population 65.13 million

The SPARES network collect data from voluntary hospital settings. The PRIMO network collect data from voluntary community laboratories on community patients or patients in LTCF. In addition, data from three hospital laboratories networks (get together in Onerba network) are sent to ECDC as the French contribution to EARS-Net.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

2237 surveillance sites participating to the national surveillance system

991 hospitals (SPARES Network)

1016 laboratories (outpatients facilities)

230 laboratories (log-term care facilities, PRIMO Network)

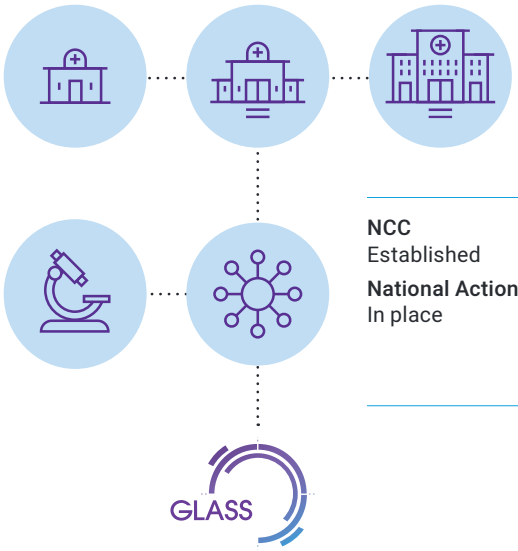
Number of laboratories performing AST not reported
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
193 laboratories for *S. pneumoniae* and 46 laboratories for the other EARS-Net pathogens reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2014
Number of data points[2]	14
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Gabon

Population 2.17 million

Due to the challenges linked to data collection in hospitals, the AMR surveillance system is currently only based on the surveillance done by the national reference laboratories.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

2
laboratories participating to the national surveillance system[a]

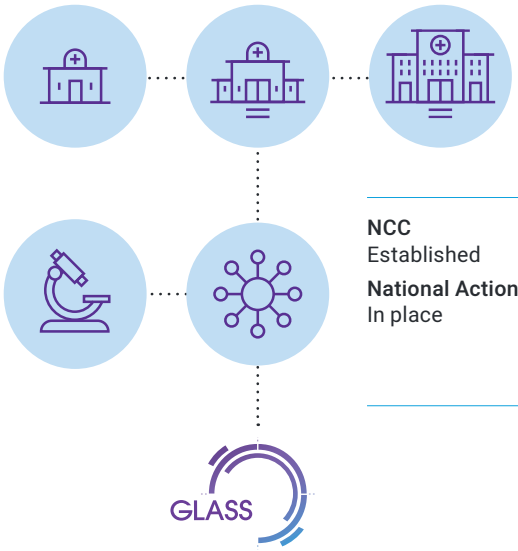
2 laboratories performing AST
EQA not provided

NRL
Established

AST standard
Not reported

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

a 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

Gambia

Population 2.35 million

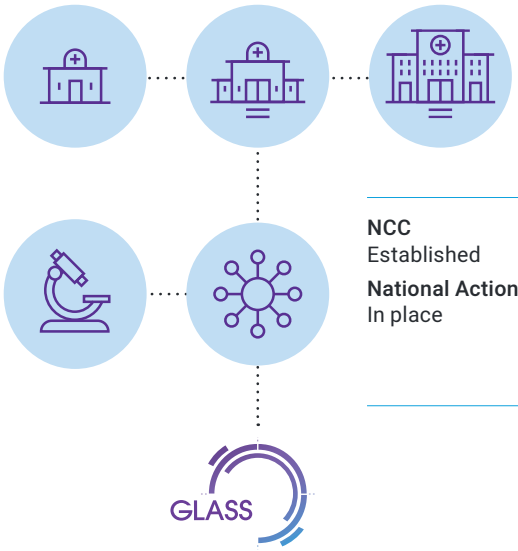
SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

Number of laboratories performing AST not reported
EQA not provided



NRL
Established

AST standard
CLSI

EQA
Provided

NCC
Established

National Action Plan
In place

in 2020 data call
No AMR data reported to GLASS

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2000
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Georgia

Population 3.72 million

The National AMR reference laboratory capacity at Lugar Center has been strengthened in terms of antimicrobial resistance surveillance capability and verified and implemented phenotypic and molecular confirmatory tools of AMR mechanism, including sequencing.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

23
laboratories participating to the national surveillance system[a]

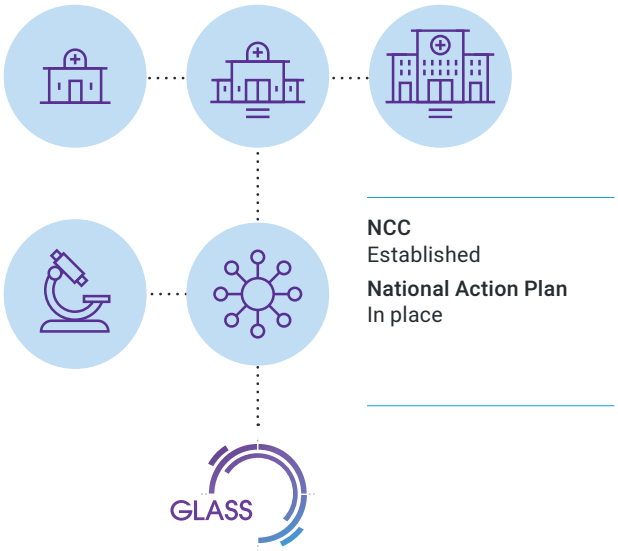
23 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
Number of surveillance sites providing data to GLASS not reported



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	12
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

a The identification of the total number of participating laboratories submitting data to GLASS was not possible due to the set-up of the National surveillance system

Germany

Population 83.52 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). Germany participates in EARS-NET and is enrolled in GLASS since September 2016.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

19835 surveillance sites participating to the national surveillance system

675 hospitals

19160 outpatient facilities

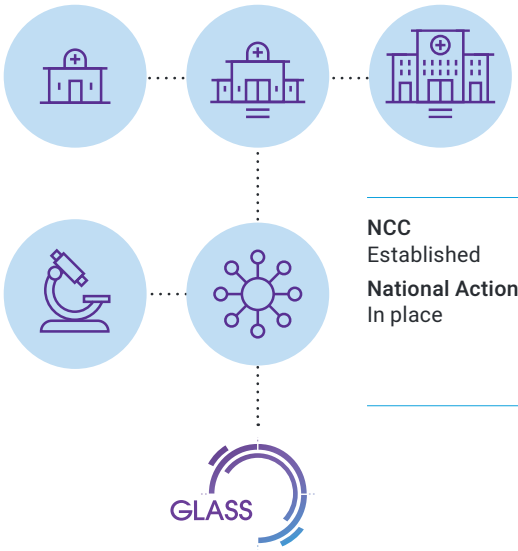
54 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
number of national surveillance sites reporting to GLASS not available[a]



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2015
Number of data points[2]	19
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

a The identification of the total number of surveillance sites submitting data to GLASS was not possible due to the set-up of the National surveillance system, however the number differs from the number of national surveillance sites by a small fraction

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Greece

Population 10.47 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

56
surveillance sites participating to the national surveillance system

56
hospitals

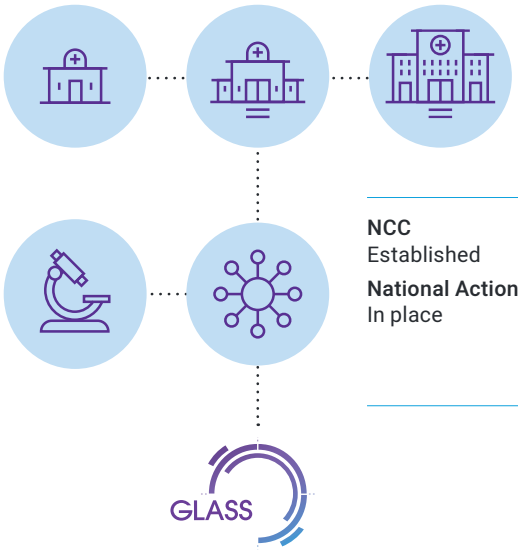
56 laboratories performing AST
EQA provided to all laboratories

NRL
Not established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
36 surveillance sites providing data to GLASS (36 hospitals)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2010
Number of data points[2]	4
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

India

Population 1.37 billion

The National Center for Disease Control (NCDC) is the national coordinating center for AMR surveillance and is coordinating the National programme on AMR Containment. Under this programme, the National AMR surveillance network has been established during 2014–15.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

71 surveillance sites participating to the national surveillance system

69 hospitals

2 outpatient facilities

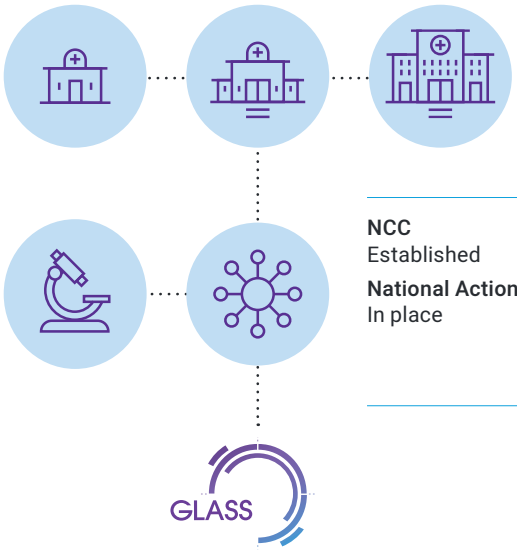
71 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Not provided

in 2020 data call
59 surveillance sites providing data to GLASS
(57 hospitals)
(2 outpatient facilities)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2016
Number of data points[2]	1
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to SURVNET1 (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
Blood	Acinetobacter spp.	●	●	●	●	
	E. coli	●	●	●	●	
	K. pneumoniae	●	●	●	●	●
	Salmonella spp.	●	●	●	●	
	S. aureus	●	●	●	●	
Urine	E. coli	●	●	●	●	
	K. pneumoniae	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

India (continued)

AMR data submission to SURVNET2 (2020 data call)						
Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
Blood	Acinetobacter spp.	●	●	●	●	
	E. coli	●	●	●	●	
	K. pneumoniae	●	●	●	●	●
	Salmonella spp.	●	●	●	●	
	S. aureus	●	●	●	●	
Urine	E. coli	●	●	●	●	
	K. pneumoniae	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

AMR data submission to SURVNET3 (2020 data call)						
Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
Blood	Acinetobacter spp.	●	●	●	●	
	E. coli	●	●	●	●	
	K. pneumoniae	●	●	●	●	●
	Salmonella spp.	●	●	●	●	
	S. aureus	●	●	●	●	
Stool	Salmonella spp.	●	●	●	●	●
Urine	E. coli	●	●	●	●	
	K. pneumoniae	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

AMR data submission to SURVNET4 (2020 data call)						
Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
Genital	N. gonorrhoeae	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Indonesia

Population 270.63 million

Indonesia also completed the first phase of the Global Integrated Survey on ESBL producing E.coli–Tricycle Project which aimed to strengthen the antimicrobial resistance (AMR) surveillance system and promote integrated surveillance across human, animal and environment sectors using the One Health approach.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

20 surveillance sites participating to the national surveillance system

20 hospitals

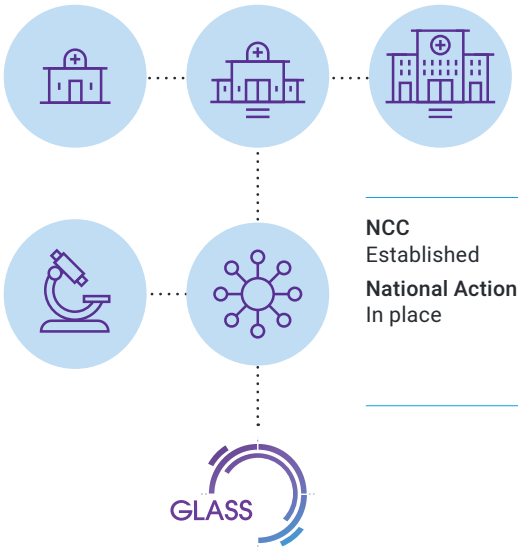
20 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
16 surveillance sites providing data to GLASS (16 hospitals)



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2016
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Iran (Islamic Republic of)

Population 82.91 million

Iran has developed an AMR National Action Plan.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

8 surveillance sites participating to the national surveillance system

8 in-out patient facilities

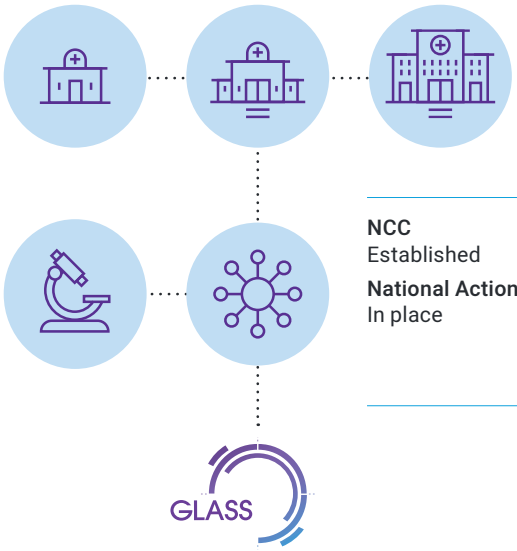
8 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2014
Number of data points[2]	2
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Iraq

Population 39.31 million

Iraq adopted a national program for AMR and announced the publication of the national action plan in 2019. The national program ensures that AMR surveillance is part of the work-plan of all primary, secondary and tertiary health care levels.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

42 surveillance sites participating to the national surveillance system

26 hospitals

2 outpatient facilities

14 in-out patient facilities

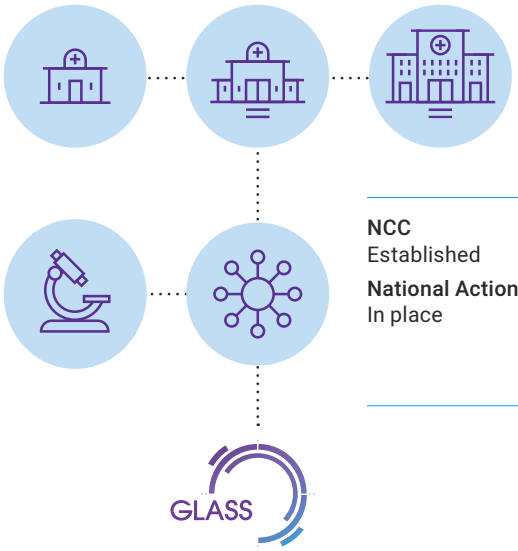
26 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Not provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2013
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Ireland

Population 4.88 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

60
surveillance sites participating to the national surveillance system

60
hospitals

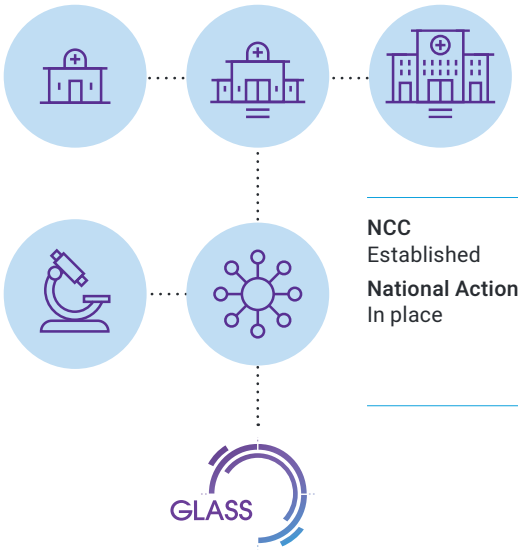
38 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2015
Number of data points[2]	16
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Italy

Population 59.64 million

The National Antibiotic Resistance Surveillance System (AR-ISS) has been running since 2001 under the coordination of Istituto Superiore di Sanità (ISS) and has enrolled hospital microbiology laboratories over the country to provide AST data following the EARS-Net (previously EARSS) protocols.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

310
surveillance sites participating to the national surveillance system

310
hospitals[a]

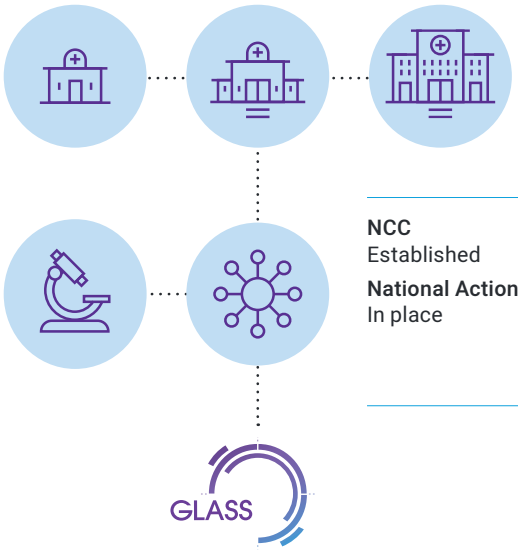
130 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
number of national surveillance sites reporting to GLASS not available[b]



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2015
Number of data points[2]	14
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

a number of hospitals including outpatient facilities not available

b The identification of the total number of surveillance sites submitting data to GLASS was not possible due to the set-up of the National surveillance system

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Japan
Population 126.86 million

The AMR surveillance in National Epidemiological Surveillance of Infectious Diseases (NESID) entails pathogen (laboratory-based surveillance) and patient reporting. The Japan Nosocomial Infections Surveillance (JANIS) collects comprehensive specimen-based data from diagnostic microbiology laboratories of participating hospitals.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

2121 surveillance sites participating to the national surveillance system

2121 hospitals

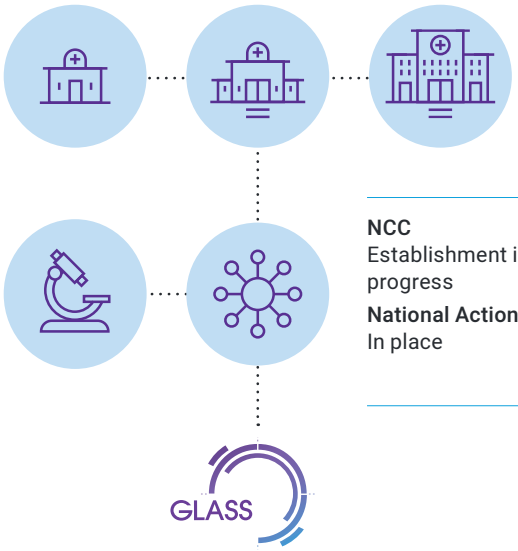
2121 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Not provided

in 2020 data call
2075 surveillance sites providing data to GLASS (2075 hospitals)



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2002
Number of data points[2]	2
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Jordan

Population 10.1 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

15 surveillance sites participating to the national surveillance system

15 in-out patient facilities

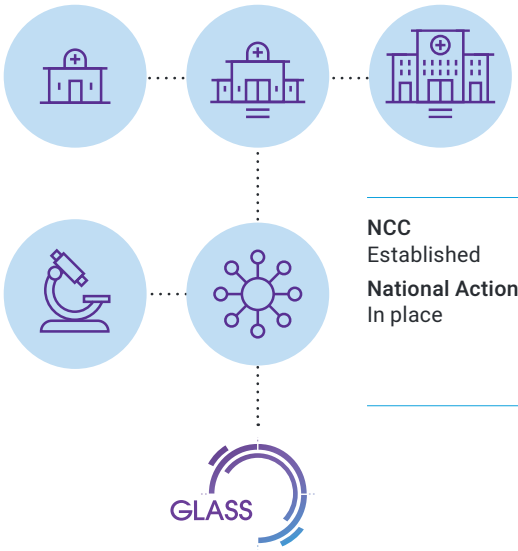
15 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	3
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Kenya

Population 52.57 million

The country is in the process of cleaning and preparing AMR reports for the next year.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

5
surveillance sites participating to the national surveillance system

5
in-out patient facilities

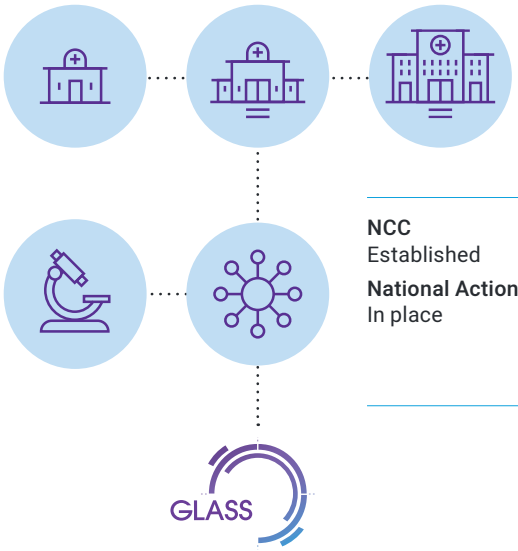
5 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2014
Number of data points[2]	2
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Kosovo

Population 1.8 million

Within the framework of National Action Plan for AMR, the National Surveillance of AMR was established in 2014.

Antibiotic susceptibility data, based on EUCAST guidelines, are sent from the sites to the National Institute of Public Health of Kosovo.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	
One health	
EGASP	

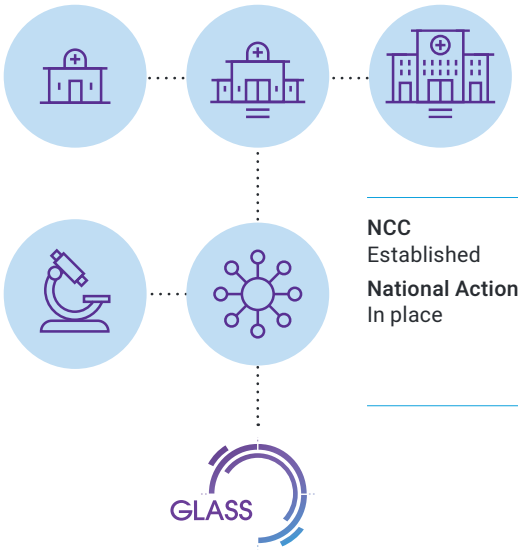
1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

7
laboratories participating to the national surveillance system[a]

7 laboratories performing AST
EQA provided to all laboratories



NRL
Established

AST standard
EUCAST

EQA
Provided

NCC
Established

National Action Plan
In place

in 2020 data call
all national participating laboratories reported to GLASS

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

a 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

Lao People's Democratic Republic

Population 7.17 million

Lao People's Democratic Republic has been expanding its national AMR surveillance system. Four additional surveillance sites were established in 2020. The AMR Surveillance Strategy and related protocols were endorsed and disseminated in March 2020.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

6 surveillance sites participating to the national surveillance system

3 hospitals

3 in-out patient facilities

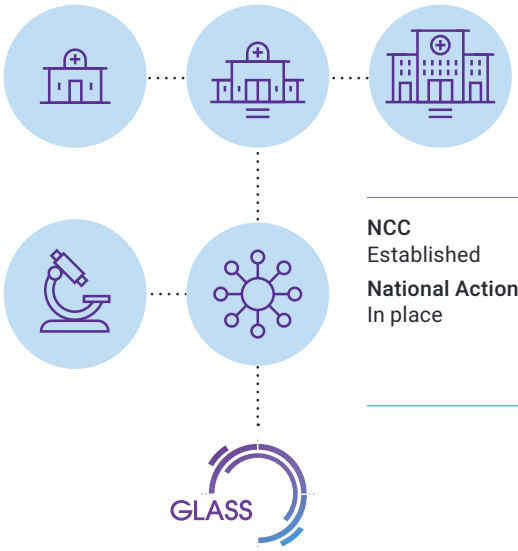
3 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
3 surveillance sites providing data to GLASS (3 hospitals)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Latvia

Population 1.91 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

15 surveillance sites participating to the national surveillance system

12 hospitals

3 in-out patient facilities

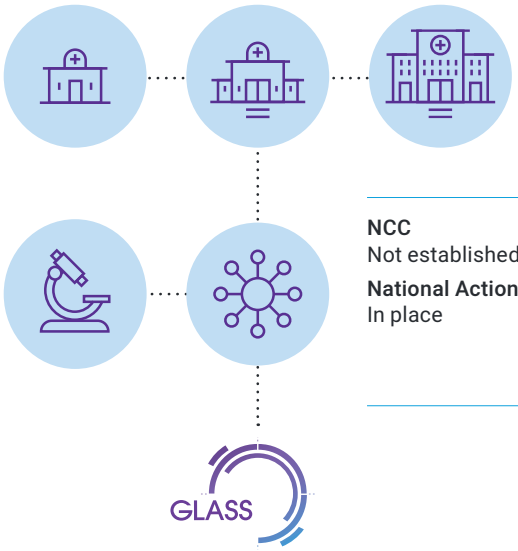
12 laboratories performing AST
EQA not provided

NRL
Not established

AST standard
EUCAST

EQA
Provided

in 2020 data call
1 surveillance site providing data to GLASS (1 in-out patient facility)



NCC
Not established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2017
Number of data points[2]	21
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Lebanon

Population 6.86 million

The main activities related to AMR surveillance accomplished aim at ensuring sustainability of AMR data Reporting to GLASS, and run WHONET training and AMR Proficiency Testing in laboratories.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

10 surveillance sites participating to the national surveillance system

10 in-out patient facilities

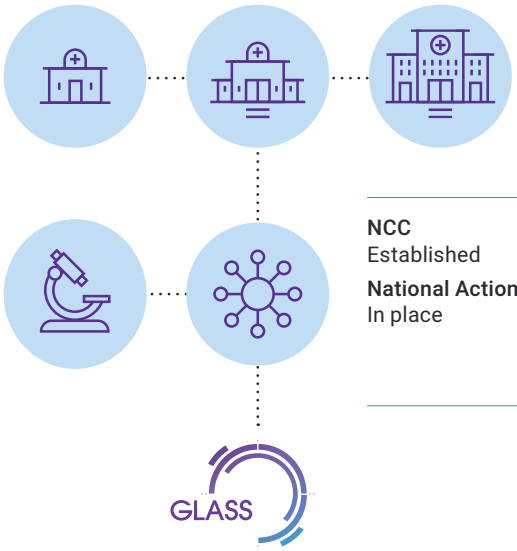
10 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
8 surveillance sites providing data to GLASS (8 in-out patient facilities)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	5
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Libya

Population 6.78 million

Because of the civil war that toke hold of the country during the last few years and the deteriorating of the health services, most of the selected surveillance sites were not able to function and start collecting data.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

1 surveillance site participating to the national surveillance system

1 hospital

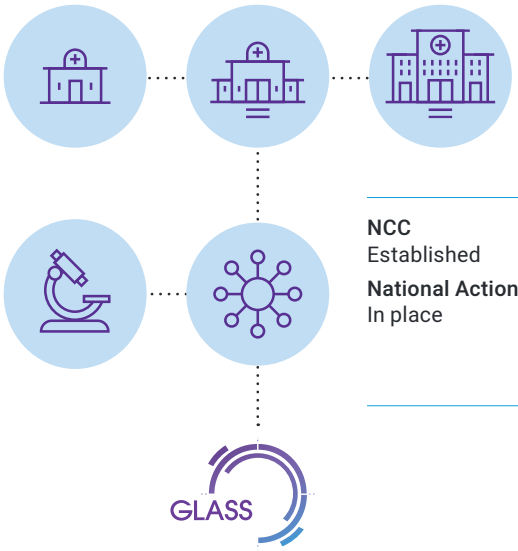
0 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	🔴	🔴	🔴	🔴	🟠

🟢 70-100% data reported 🟠 <70% data reported 🔴 No data reported

Lithuania

Population 2.76 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

40 surveillance sites participating to the national surveillance system

20 hospitals

20 in-out patient facilities

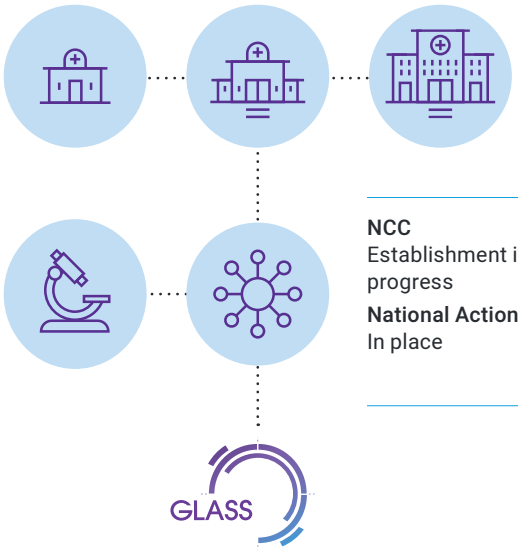
20 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
35 surveillance sites providing data to GLASS
(10 hospitals)
(15 outpatient facilities)
(10 in-out patient facilities)



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	20
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Luxembourg

Population 0.62 million

Within the framework of the National plan, a platform for centralising data on antibiotic resistance from the human and veterinary sectors will be set up under the responsibility of the LNS (National Health Laboratory).

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

8 surveillance sites participating to the national surveillance system

4 hospitals

4 in-out patient facilities

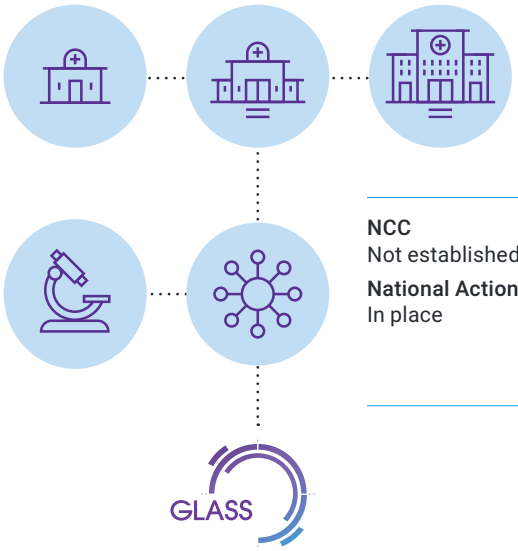
8 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Not established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2014
Number of data points[2]	11
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Madagascar

Population 26.97 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

9
surveillance sites participating to the national surveillance system

9
in-out patient facilities

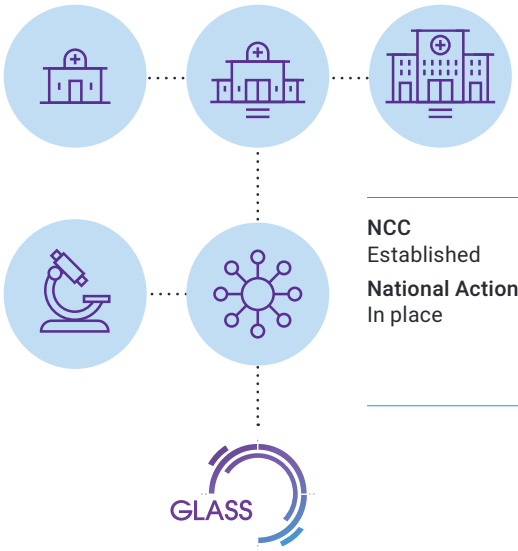
9 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2007
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Malawi

Population 18.63 million

A guiding document for AMR surveillance has been developed and implementation is underway.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

14 surveillance sites participating to the national surveillance system

14 in-out patient facilities

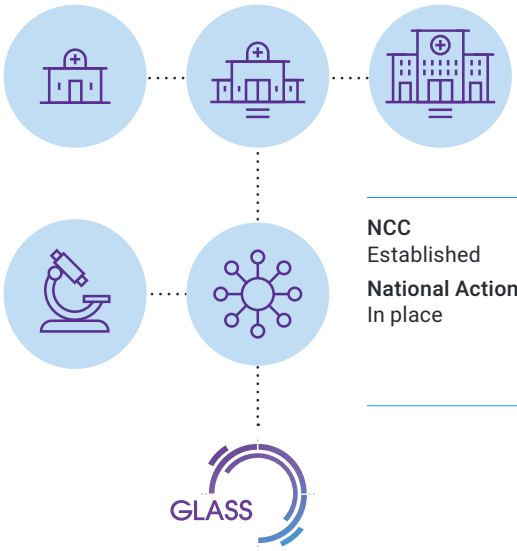
14 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
8 surveillance sites providing data to GLASS (8 in-out patient facilities)



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance		
National survey	**Data**	**Year[1]**
Pretreatment HIV DR (adults)	●	2018
Pretreatment HIV DR (infants)	●	2016
Acquired HIV DR (adults)	●	2018
Acquired HIV DR (children)	●	2018

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Malaysia

Population 31.95 million

The National Surveillance of Antibiotic Resistance was established in 2000 and started with only 6 major hospitals to gradually increase to 42 hospitals and 1 public health laboratory in 2020. Antibiotic susceptibility data from the participating laboratories are sent to the Institute for Medical Research (IMR), Ministry of Health Malaysia.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

43 surveillance sites participating to the national surveillance system

42 hospitals

1 outpatient facilities

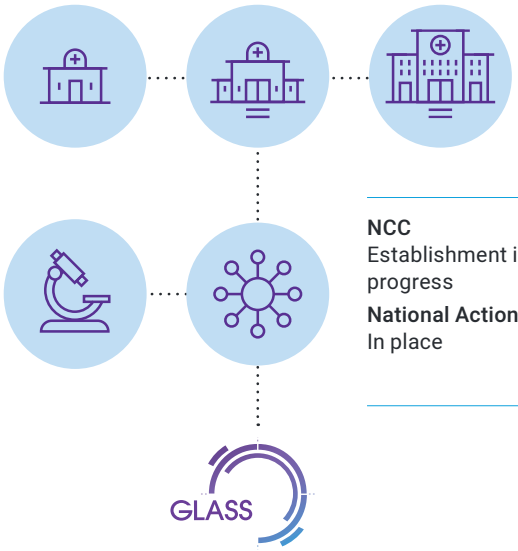
0 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Mali

Population 19.66 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

5 surveillance sites participating to the national surveillance system

5 in-out patient facilities

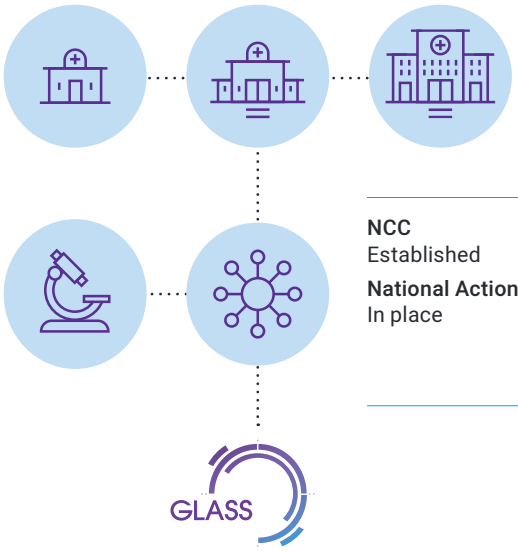
5 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Malta

Population 0.44 million

The microbiology laboratory at Mater Dei Hospital provides diagnostic services to all public primary, secondary and tertiary care facilities. It is estimated that this covers more than 95% of inpatient care. There is no national AMR surveillance in Malta, but data are generated by surveillance on bacteraemia.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

14 surveillance sites participating to the national surveillance system

4 hospitals

10 outpatient facilities

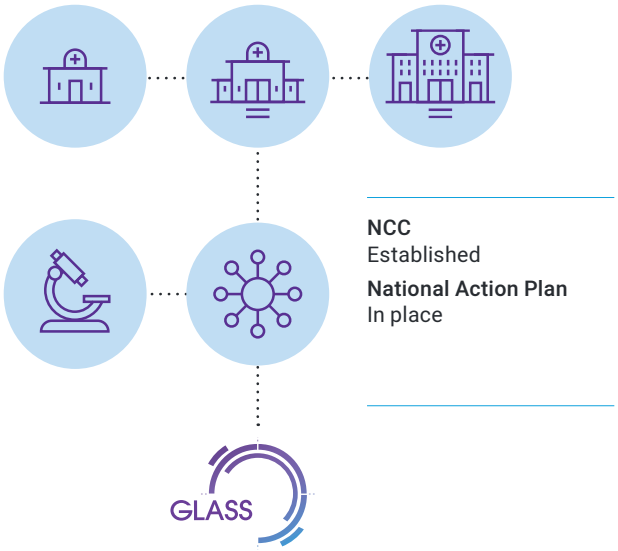
1 laboratory performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	15
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Mauritius

Population 1.27 million

AMR data is currently collected in paper-based format and no electronic system is available to support data analysis.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

154 surveillance sites participating to the national surveillance system

13 hospitals

141 outpatient facilities

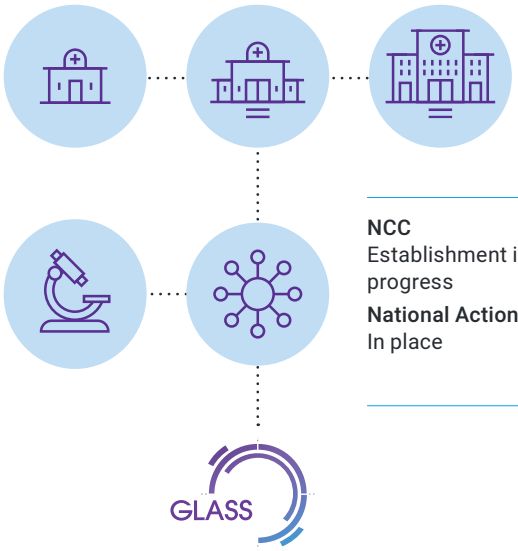
2 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	10
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Mozambique

Population 30.37 million

AMR surveillance is focusing on blood stream infections identified as part of routine patient care at a general hospital in the peri urban area of Maputo City. The surveillance is being carried out by the Instituto Nacional de Saúde of Mozambique.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

1 surveillance site participating to the national surveillance system

1 in-out patient facility

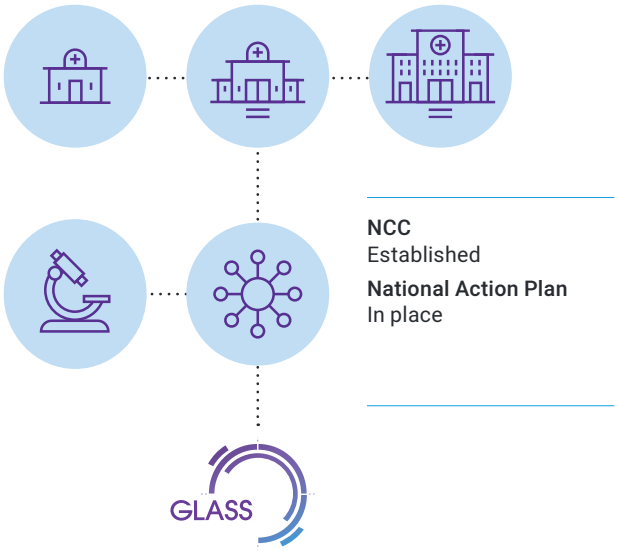
1 laboratory performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	
Pretreatment HIV DR (infants)	●	2012
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2007
Number of data points[2]	2
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Myanmar

Population 54.05 million

National multi-sectoral steering committee (NMSC) combating Myanmar was endorsed on 22nd January 2018, consisting of 19 members in multi-sectoral and one health approach. Furthermore, WHO listed National Coordinating Centre (NCC) located at NHL, Yangon, was established in June 2018.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

13 surveillance sites participating to the national surveillance system

- **6** hospitals
- **1** outpatient facility
- **6** in-out patient facilities

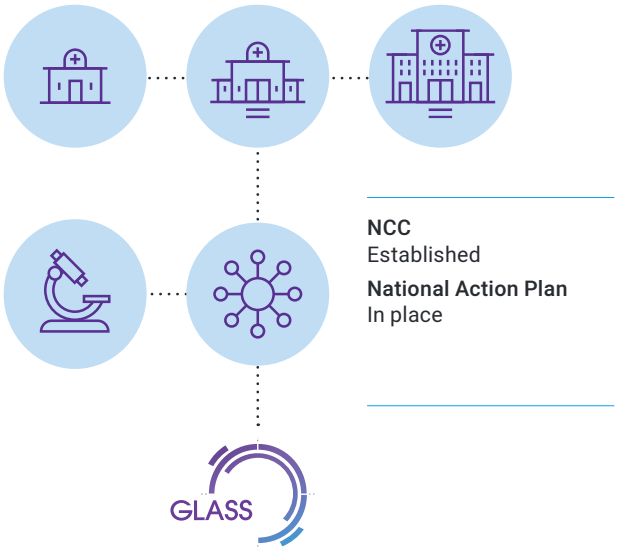
7 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2016
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	2018
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	4
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Nepal

Population 28.61 million

The data reporting for AMR surveillance is done in electronic and paper-based format. Few sites are unable to submit data due to unavailability of human or IT resources. Training regarding WHONET and data entry and analysis was provided with the help of Fleming Fund Country Grant and data was made available.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

41 surveillance sites participating to the national surveillance system

- **20** hospitals
- **1** outpatient facility
- **20** in-out patient facilities

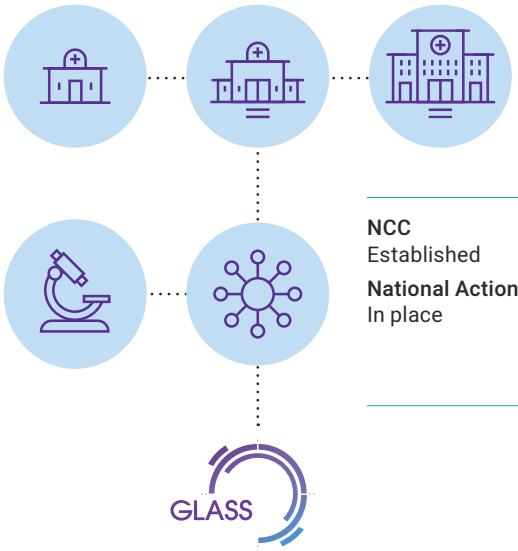
21 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
29 surveillance sites providing data to GLASS
(14 hospitals)
(1 outpatient facility)
(14 in-out patient facilities)



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2016
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2011
Number of data points[2]	5
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Netherlands

Population 17.10 million

Since 1996, results of antimicrobial susceptibility testing of isolates routinely tested in medical microbiology laboratories in the Netherlands are studied and since 2008 these data are systematically collected in the Infectious Diseases Surveillance Information System–Antimicrobial Resistance (ISIS-AR). This surveillance system is coordinated by the Centre for Infectious Disease Control at the National Institute for Public Health and the Environment. National data on both human and animal antimicrobial resistance and antimicrobial use are presented in the yearly report NethMap/MARAN.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

53
laboratories participating to the national surveillance system[a]

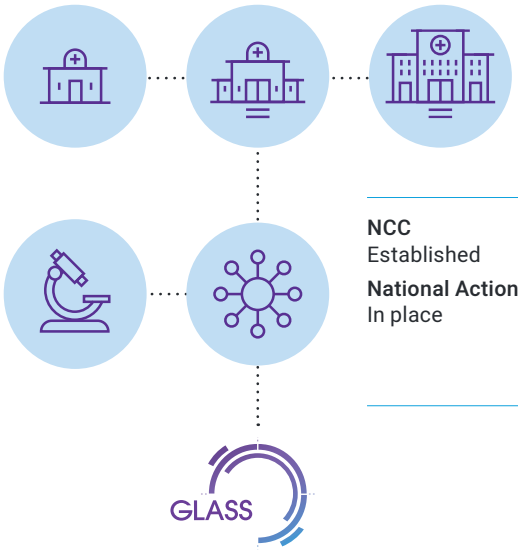
53 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
35 laboratories reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	23
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

a 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

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Norway
Population 5.38 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

22
laboratories participating to the national surveillance system[a]

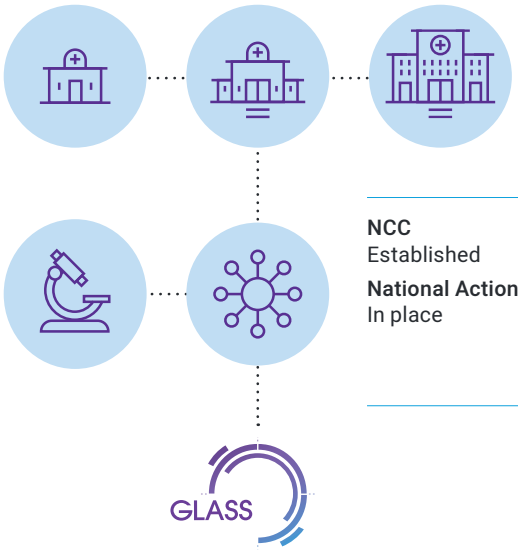
22 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national participating laboratories reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	21
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

a 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

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Occupied Palestinian territory, including east Jerusalem

Population 4.98 million

The country is setting up the National Reference Laboratory to receive bacterial isolates from different sites. The national action plan for AMR is waiting for approval.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

13 surveillance sites participating to the national surveillance system

13 hospitals

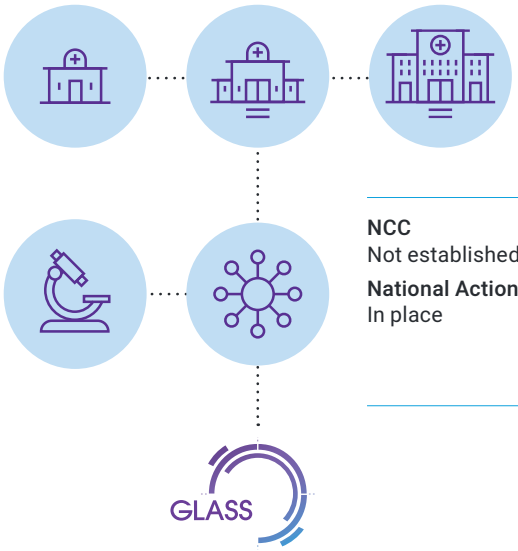
Number of laboratories performing AST not reported
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Not Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Not established

National Action Plan
In place

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Oman

Population 4.47 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

16 surveillance sites participating to the national surveillance system

8 outpatient facilities

8 in-out patient facilities

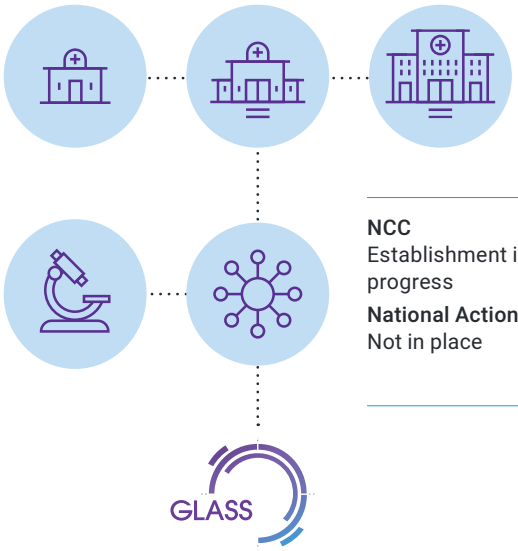
8 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
Not in place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	10
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Pakistan

Population 216.57 million

Pakistan started AMR surveillance with the enrollment in GLASS in 2017. In 2019, the National Surveillance System has been established. The primary goal of the AMR surveillance system is to generate evidence on the burden of antimicrobial drug resistance among priority pathogens.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

40 surveillance sites participating to the national surveillance system

19 hospitals

1 outpatient facility

20 in-out patient facilities

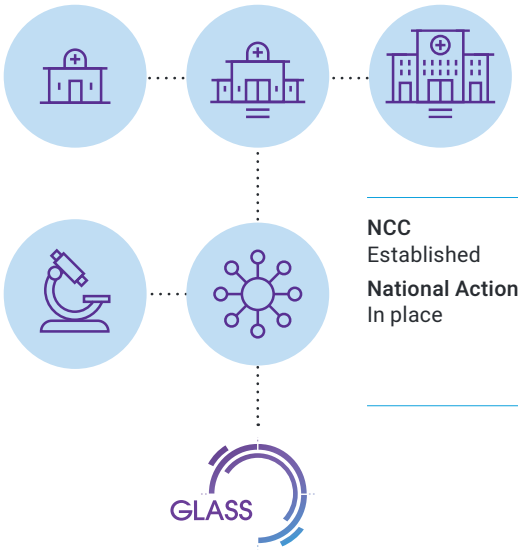
20 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
22 surveillance sites providing data to GLASS
(10 hospitals)
(1 outpatient facility)
(11 in-out patient facilities)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2013
Number of data points[2]	1
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Peru

Population 32.51 million

The Antimicrobial Resistance Surveillance System in Peru is coordinated by the National Institute of Health, Ministry of Health. Peru is implementing the AMR National Action Plan published in 2019 and has been enrolled to GLASS in August 2019.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

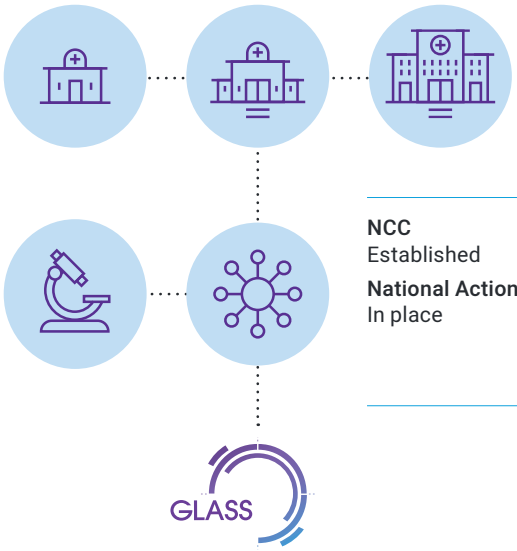
Number of laboratories performing AST not reported
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
number of surveillance sites providing data to GLASS not reported



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2016
Number of data points[2]	7
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Philippines

Population 108.12 million

The Philippines Department of Health's national AMR surveillance – the Antimicrobial Resistance Surveillance Program (DOH-ARSP) – is a sentinel laboratory-based surveillance established in 1988. It has 24 sentinel sites and 2 gonorrhea surveillance sites.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	✓

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

26 surveillance sites participating to the national surveillance system

26 hospitals

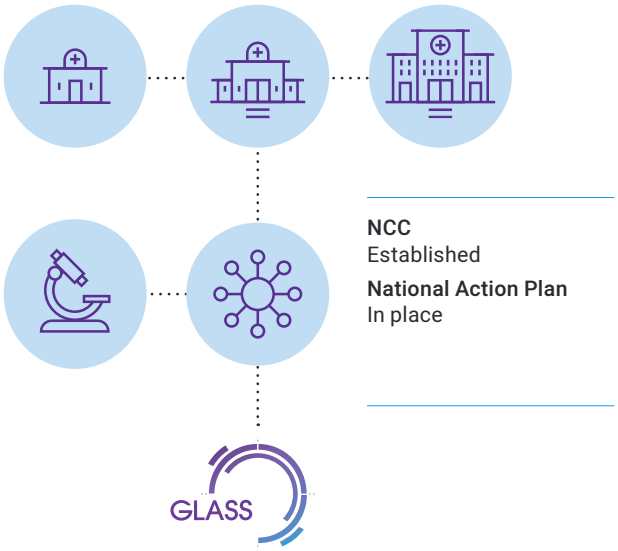
26 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	3
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Poland

Population 37.89 million

Data reported to the AMR surveillance are obtained from laboratories participating in EARS-Net. The national EARS-Net coordination center is located in the National Reference Centre for Susceptibility Testing (NRCST). All EARS-Net laboratories participate in the National External Quality Programme (POLMICRO).

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

61 surveillance sites participating to the national surveillance system

61 hospitals

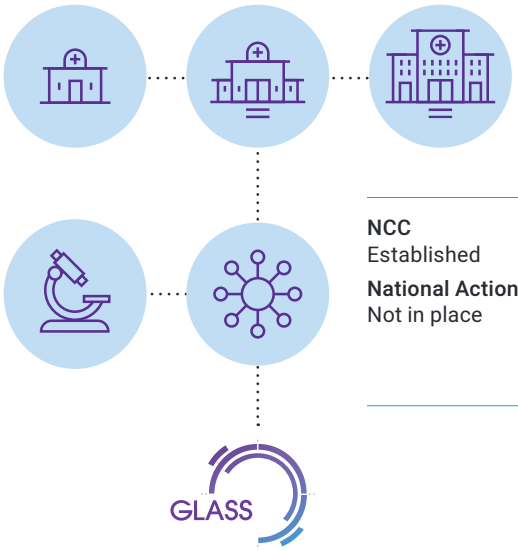
56 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
Not in place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	13
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Qatar

Population 2.83 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

58 surveillance sites participating to the national surveillance system

15 hospitals

28 outpatient facilities

15 in-out patient facilities

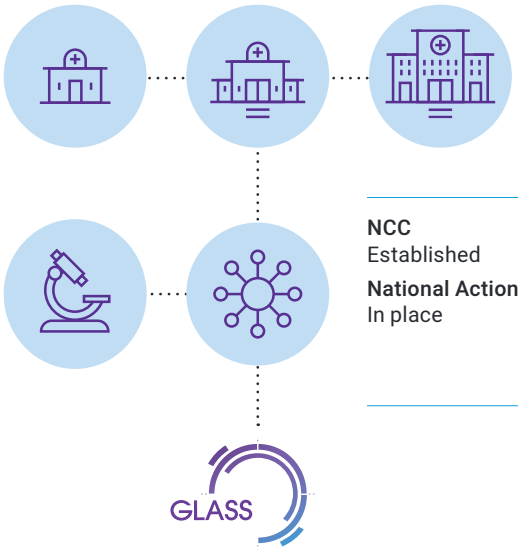
4 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
47 surveillance sites providing data to GLASS
(4 hospitals)
(28 outpatient facilities)
(15 in-out patient facilities)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	8
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Republic of Korea

Population 25.67 million

Depending on the domestic situation, it is adding pathogens and examining resistant genes or virulence genes.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

8 surveillance sites participating to the national surveillance system

8 hospitals

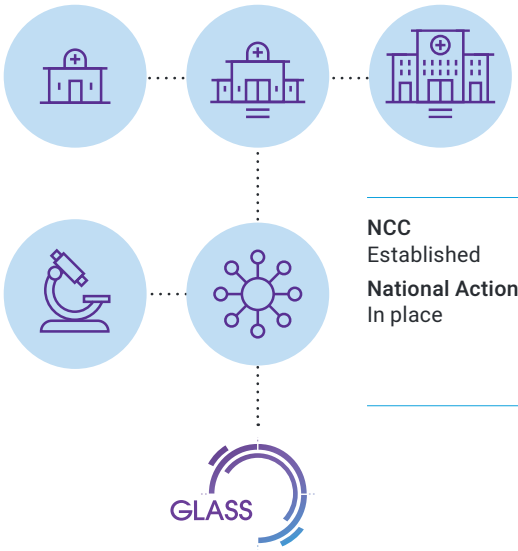
5 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	7
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Russian Federation

Population 146.75 million

The National AMR Surveillance network comprises of about 50 laboratories that provide microbiological service for more than 65 medical facilities. The central laboratory of Institute of Antimicrobial Chemotherapy annually collects from each participating medical center clinical isolates together with anonymous patient clinical and epidemiological data.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

65 surveillance sites participating to the national surveillance system

55 hospitals

10 in-out patient facilities

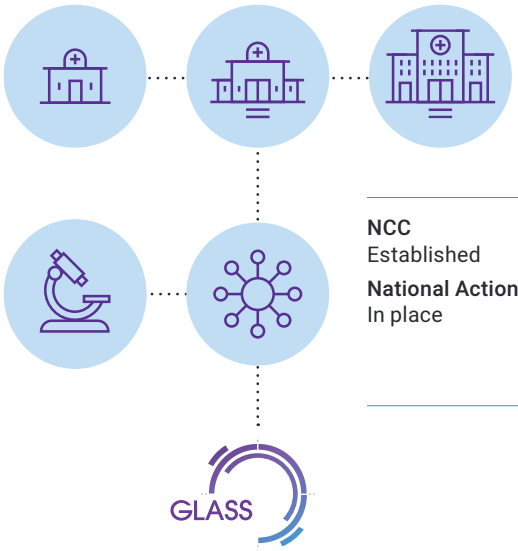
46 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
14 surveillance sites providing data to GLASS (14 hospitals)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	4
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Saudi Arabia

Population 34.27 million

In Saudi Arabia the national surveillance data is provided by hospitals microbiology laboratories, The data is collected and analyzed by the national coordinating center under the Public health authority.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

31 surveillance sites participating to the national surveillance system

31 hospitals

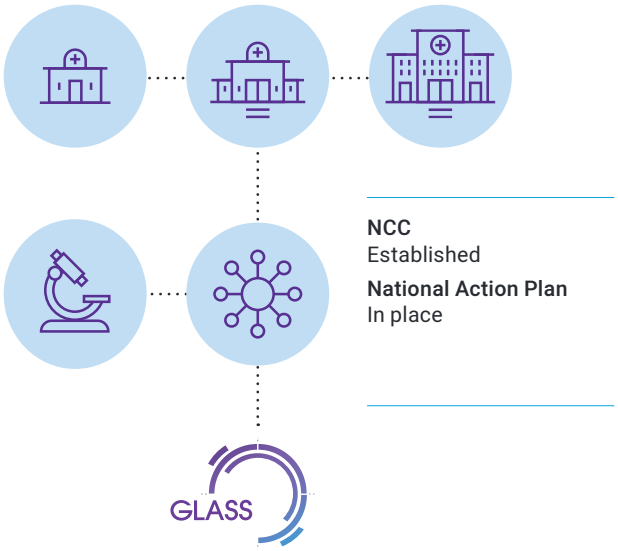
31 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2010
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Singapore

Population 5.80 million

Singapore has been conducting surveillance of AMR since 2011. AMR surveillance in human health is overseen by the National Antimicrobial Resistance Control Committee (NARCC). NARCC collects, integrates and analyses data on AMR, antimicrobial use and stewardship from all acute care hospitals twice yearly and provides the information annually to the hospitals and the Ministry of Health.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

18 surveillance sites participating to the national surveillance system

17 hospitals

1 outpatient facility

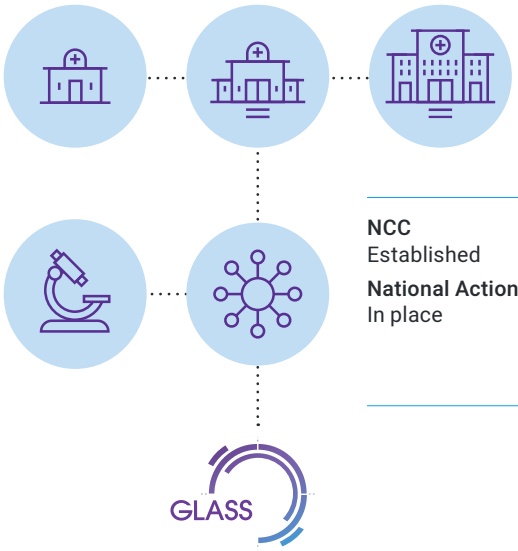
14 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI/Others

EQA
Provided

in 2020 data call
3 surveillance sites providing data to GLASS
(2 hospitals)
(1 outpatient facility)



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	20
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

South Africa

Population 58.56 million

For GLASS in South Africa under the National Institute for Communicable Diseases (NICD) umbrella, three surveillance programmes are utilized for reporting the appropriate data. These surveillance programmes include GERMS-SA laboratory-based surveillance, NICD sentinel periodic surveillance for sexually transmitted infections (STIs) and the National AMR routine electronic surveillance.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

737 surveillance sites participating to the national surveillance system

535 hospitals

200 outpatient facilities

2 in-out patient facilities

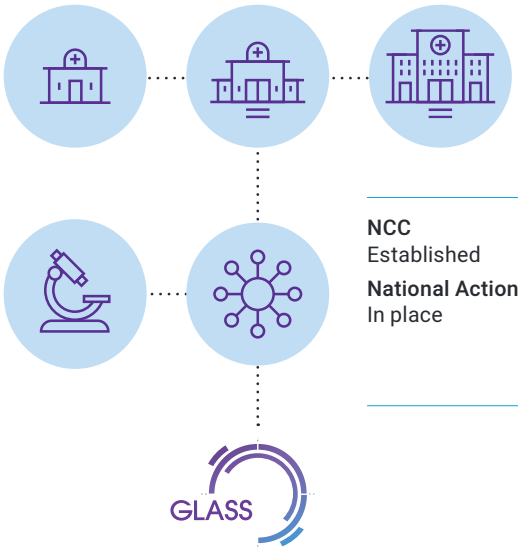
79 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
208 surveillance sites providing data to GLASS
(200 hospitals)
(6 outpatient facilities)
(2 in-out patient facilities)



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2017
Pretreatment HIV DR (infants)	●	2014
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2014
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Sri Lanka

Population 21.32 million

Surveillance on antimicrobial resistance has been carried out since 2009 in a limited number of sites. The programme was further strengthened and upgraded in 2018 to include 25 hospital covering all parts of the country.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

18 surveillance sites participating to the national surveillance system

18 hospitals

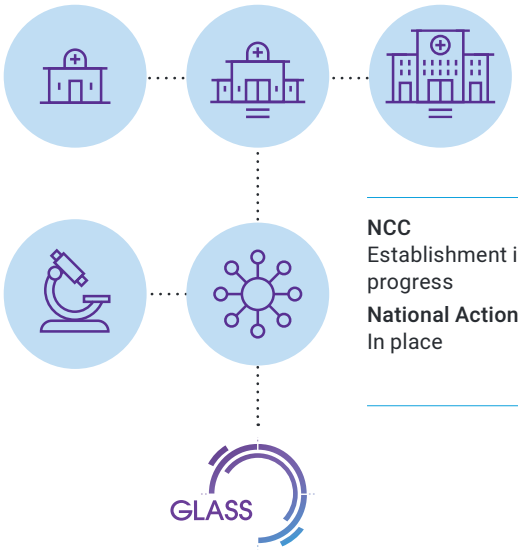
18 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Sweden

Population 10.38 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. The Public Health Agency of Sweden and the National Veterinary Institute analyses and compile national data on antibiotic sales and resistance in an annual report, SWEDRES/SVARM.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

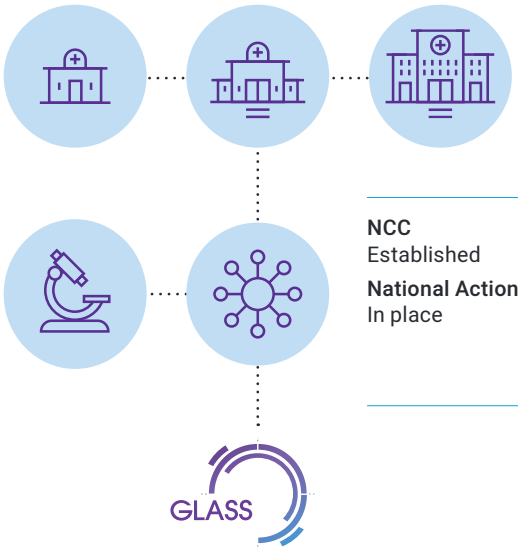
Indicators reported to GLASS

1231 surveillance sites participating to the national surveillance system

84 hospitals

1147 outpatient facilities

26 laboratories performing AST
EQA not provided



NRL
Established

AST standard
EUCAST

EQA
Provided

NCC
Established

National Action Plan
In place

in 2020 data call
20 participating laboratories reported to GLASS
(20 laboratories)

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	21
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Switzerland

Population 8.59 million

The Swiss Antibiotic Resistance Centre (www.anresis.ch) was established in 2004. It collects all routinely performed AMR results from laboratories distributed all over Switzerland covering >85% of all hospitalization days. Besides samples from hospitals, it also includes samples from private physicians and long-term facilities.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

9470 surveillance sites participating to the national surveillance system

157 hospitals

9313 outpatient facilities

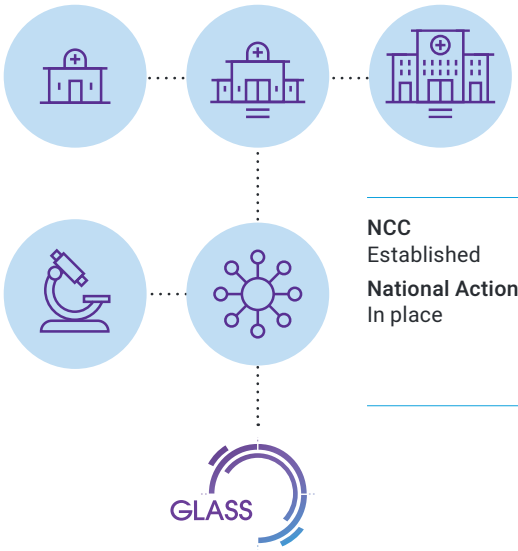
33 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	19
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Syrian Arab Republic

Population 17.07 million

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

4
surveillance sites participating to the national surveillance system

4
in-out patient facilities

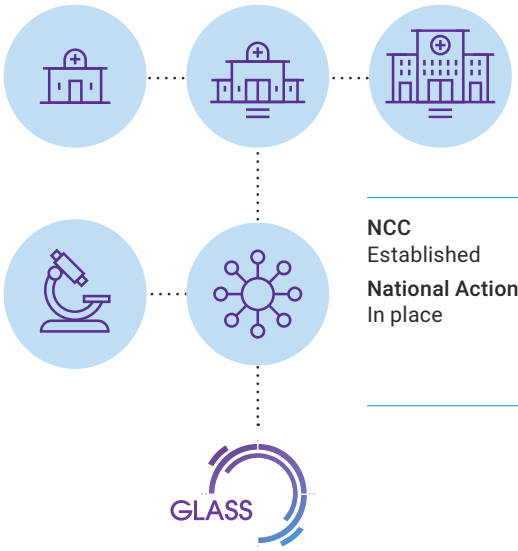
4 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST/CLSI

EQA
Not provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	2
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Thailand

Population 69.63 million

AMR data are collected quarterly and are analyzed at national and regional level. This information (e.g., antibiogram and resistance trend) is available on http://narst.dmsc.moph.go.th.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	✓

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

92 surveillance sites participating to the national surveillance system

91 hospitals

1 outpatient facility

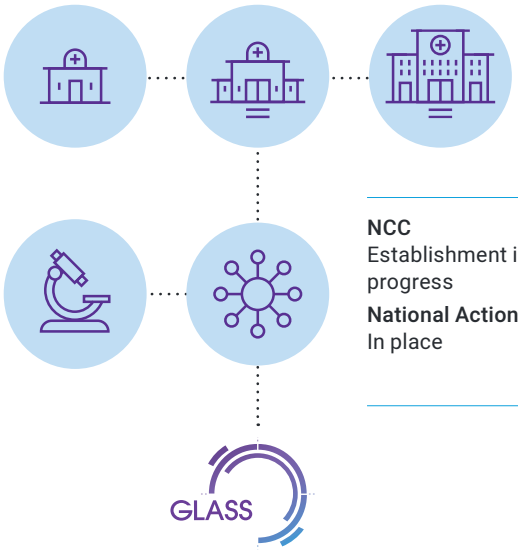
92 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
10 surveillance sites providing data to GLASS
(9 hospitals)
(1 outpatient facility)



NCC
Establishment in progress

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2016
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	5
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Timor-Leste

Population 1.29 million

The country is establishing a national coordination structure for surveillance of AMR in the Ministry of Health and the Ministry of Agriculture and Forest.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

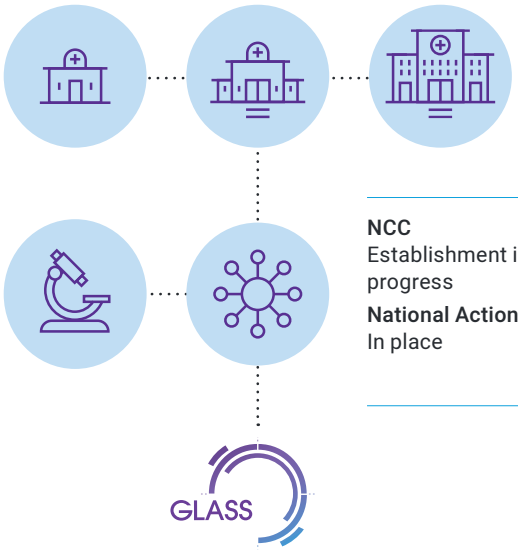
0 laboratories performing AST
EQA not provided

NRL
Established

AST standard
EUCAST

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Trinidad and Tobago

Population 1.39 million

A Regional Reference Laboratory Service (RRL) and Coordination is being developed with the Caribbean Community (CARICOM) with the assistance of the Pan American Health Organization and Argentina through a Country Cooperation for Health Development (CCHD) project.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

1 surveillance site participating to the national surveillance system

1 in-out patient facility

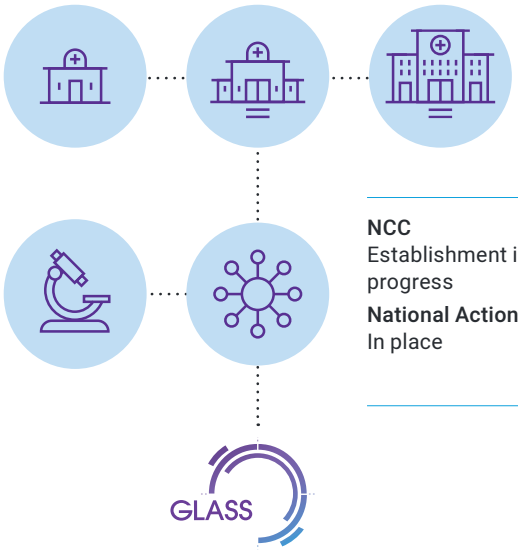
1 laboratory performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	1
Data on fluorquinolones	No

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Tunisia

Population 11.69 million

National level coordination of AMR surveillance is in the process of being set up. However, Since 1999, a voluntary microbiologist group provide data on AMR.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	✓
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

24 surveillance sites participating to the national surveillance system

12 hospitals

12 in-out patient facilities

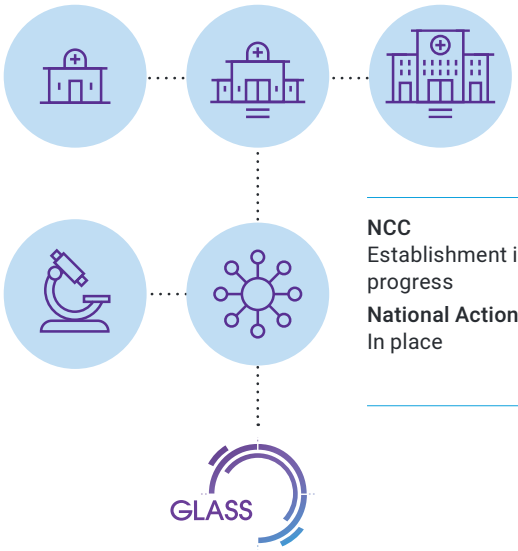
11 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST

EQA
Not provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	5
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

Uganda

Population 44.27 million

A technical team involved in training, standardization and quality assurance activities. The team operates in liaison with the National coordinator and multi-sectoral National coordinating center, as well as sites coordinators and multidisciplinary site coordinating committee.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	✓
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

3 surveillance sites participating to the national surveillance system

2 outpatient facilities

1 in-out patient facility

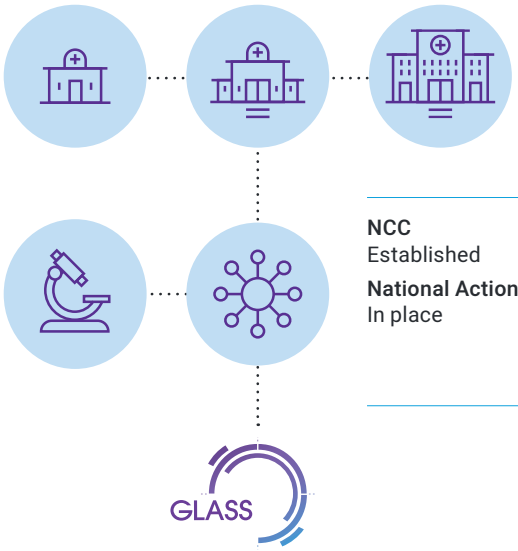
8 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2016
Pretreatment HIV DR (infants)	●	2011
Acquired HIV DR (adults)	●	2017
Acquired HIV DR (children)	●	

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	3
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

United Arab Emirates

Population 9.77 million

The United Arab Emirates have been conducting surveillance of AMR since 2011 when the Abu Dhabi – Antimicrobial Resistance Surveillance Program (AD ARS) was introduced. In 2015, the program was expanded nationwide, under the Ministry of Health and Prevention. The National Strategy and Action Plan on AMR has been approved.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

250 surveillance sites participating to the national surveillance system

79 hospitals

171 outpatient facilities

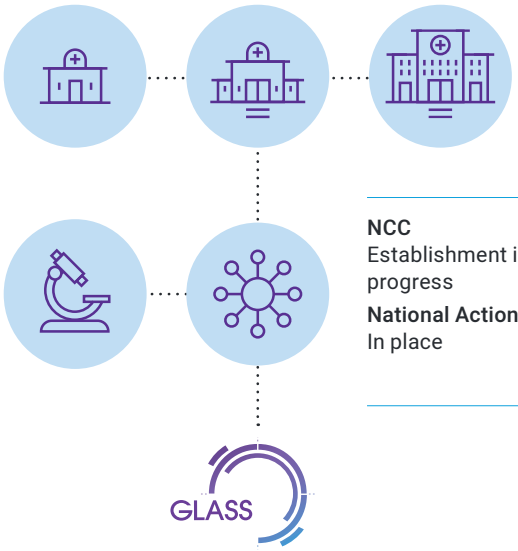
39 laboratories performing AST
EQA not provided

NRL
Not established

AST standard
CLSI

EQA
Not provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Establishment in progress

National Action Plan
In place

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

United Kingdom of Great Britain and Northern Ireland

Population 67.53 million

AMR surveillance in the UK is coordinated by Public Health England, Public Health Agency Northern Ireland, ARHAI Scotland (NHS National Services Scotland) and Public Health Wales. The UK has a Five-Year National Action Plan (2019 to 2024) and a Twenty-Year Vision for AMR.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

107
laboratory participating to the national surveillance system[a]

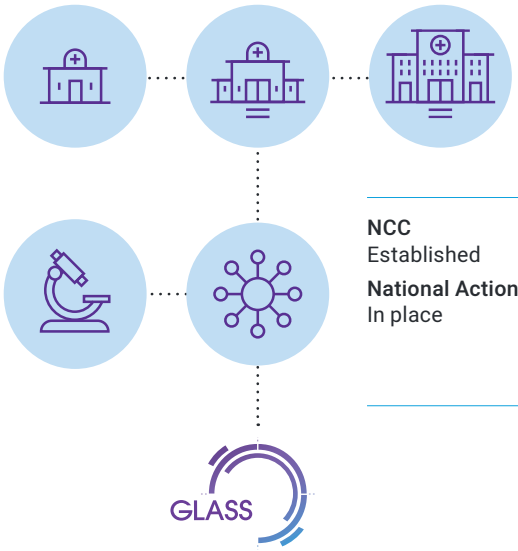
107 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
EUCAST/CLSI

EQA
Provided

in 2020 data call
all national participating laboratories reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance

High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	21
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported

a 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

United Republic of Tanzania

Population 58.01 million

United Republic of Tanzania has been building a robust system of data collection at the surveillance sites level and it is now at the initial stage of implementation.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	✓
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

63 surveillance sites participating to the national surveillance system

- **9** hospitals
- **9** outpatient facilities
- **45** in-out patient facilities

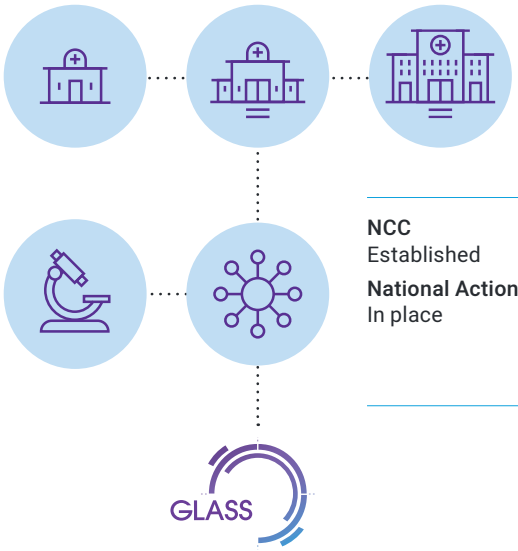
9 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	Yes
Source of data	Survey
Surveillance coverage	Nationwide
Year of most recent activity	2018
Number of data points[2]	2
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

United States of America

Population 329.07 million

AMR surveillance activities are coordinated by the Centers for Disease Control and Prevention (CDC) in conjunction with other federal, state and local public health agencies. Surveillance is directed by several national networks.

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

48126 surveillance sites participating to the national surveillance system

4035 hospitals

40600 outpatient facilities

3491 in-out patient facilities

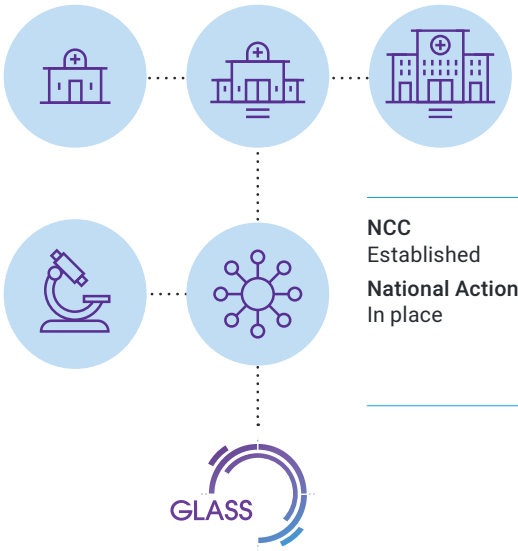
15989 laboratories performing AST
EQA provided to all laboratories

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
No AMR data reported to GLASS



NCC
Established

National Action Plan
In place

Drug-resistant TB surveillance	
High burden country[1]	No
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	27
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

Zambia

Population 17.86 million

The National multi-sectorial steering committee (NMSC) oversees and monitors activities of the Antimicrobial Resistance Coordinating Committee (AMRCC).The AMRCC is composed of sector-specific focal point persons and heads of technical working groups (TWGs).

SURVEILLANCE ACTIVITIES	IMPLEMENTATION
GLASS-AMR	✓
GLASS-AMC	
HIV DR[1]	
DR-TB[2]	✓
Malaria TES[3]	
One health	✓
EGASP	

1. HIV Drug-Resistance
2. Drug-resistant TB
3. Malaria Therapeutic Efficacy Studies

National AMR surveillance systems key indicators

Indicators reported to GLASS

3 surveillance sites participating to the national surveillance system

3 in-out patient facilities

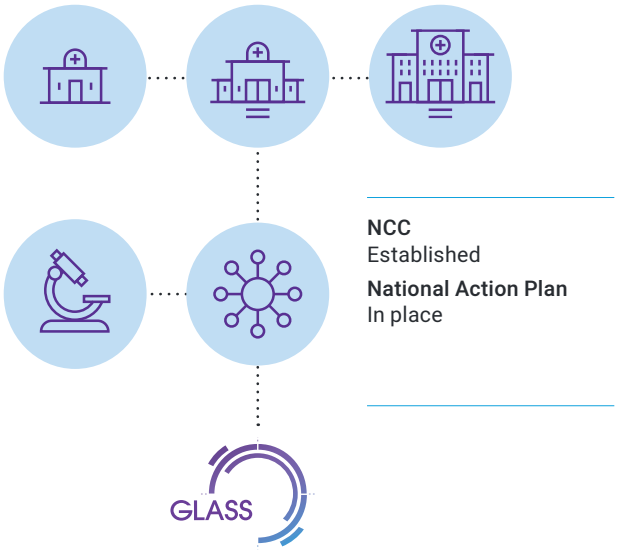
3 laboratories performing AST
EQA not provided

NRL
Established

AST standard
CLSI

EQA
Provided

in 2020 data call
all national surveillance sites reported to GLASS



NCC
Established

National Action Plan
In place

HIV drug resistance surveillance

National survey	Data	Year[1]
Pretreatment HIV DR (adults)	●	2019
Pretreatment HIV DR (infants)	●	
Acquired HIV DR (adults)	●	2016
Acquired HIV DR (children)	●	2019

● Data reported ● Data to be reported ● Data not available
1. Year of most recent survey

Drug-resistant TB surveillance

High burden country[1]	Yes
Source of data	Surveillance
Surveillance coverage	Nationwide
Year of most recent activity	2019
Number of data points[2]	4
Data on fluorquinolones	Yes

1. This indicates whether the country has been defined by WHO for the period of 2016-2020 as having a high burden of TB and/or multidrug-resistant TB (MDR-TB)
2. Number of years from which data are available between 1995 and 2019

AMR data submission to GLASS (2020 data call)

Specimen type	Pathogen	AST results	Age	Gender	Infection origin	Data on number of tested patient
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	●	●	●	●	●

● 70-100% data reported ● <70% data reported ● No data reported


SECTION
05

5. Conclusion

Despite the major challenges faced by countries during the COVID-19 pandemic, 82 out of 94 enrolled countries areas and territories reported AMR related data to GLASS during the 2020 data call. WHO acknowledges the efforts made by the reporting countries in contributing to the global AMR monitoring as a high priority to inform AMR strategies globally.

This fourth GLASS report presents the proportion of AMR in 2019 for 3 030 413 laboratory-confirmed infections reported by 70 of the countries that enrolled by the end of the AMR data call in August 2020. High rates of resistance[13] for the AMR indicators in the SDG monitoring framework and among antimicrobials frequently used to treat common bacterial infections have been observed. Of great concern is the fact that the reported rates for AMR SDG indicators in LMICs are higher compared to HICs. While this information may represent a worrisome reality, it may also be explained by different types of selection bias. Clearly, the underlying causes for these higher rates in LMICs need to be investigated as a matter of urgency.

The reported high rates of resistance in common human infections are also disquieting. If confirmed, the reported very high rate of resistance in common pathogens causing UTIs to a first-line drug such as co-trimoxazole (around 50%) may preclude empirical treatment with this agent and hamper efforts to rationalize the use of antimicrobial medicines towards a spectrum of activity as narrow as possible. This shows the importance of obtaining specific AMR information to inform national treatment guidelines. Equally disturbing is the finding of high rates of ciprofloxacin resistance in community UTI due to *E. coli* (median rate, 36.37% [IQR 24.65-49.04]) and *K. pneumoniae* (median rate, 30.47% [IQR 19.69-47-36]), the most common pathogens causing community UTI. Ciprofloxacin is a "Watch" antibiotic in the AWaRe categorization and should not be first-line treatment for community UTI. However, it is a commonly used antimicrobial to treat this infection and the high rates may suggest overuse and misuse of this medicine.

The observed rates of resistance to beta-lactams and quinolones also suggest that it would be important to conduct further studies to identify the underlying reasons for the reported high resistance rates in the involved countries, as well as to correlate these with human antimicrobial consumption data in order to inform actions to mitigate the emergence and spread of AMR.

Of most crucial concern is the emergence of carbapenem-resistant organisms. The extremely high rates of carbapenem-resistant *Acinetobacter* spp., an important pathogen causing hospital infections, as well as the non-negligible carbapenem resistance rates in *K. pneumoniae*, depict a dire scenario. Carbapenem resistance is particularly important as the pipeline for effective antimicrobials against this type of AMR is dry. The majority of antibiotics targeting the priority pathogens are beta-lactam and beta-lactamase inhibitor combinations do not sufficiently address the problem of XDR or PDR Gram-negative bacteria *(92)*. In particular, critical priority pathogens such as carbapenem-resistant *A. baumannii* and *Pseudomonas aeruginosa* are insufficiently addressed in the clinical pipeline.

The report also summarizes the implementation of AMR and AMC surveillance core components by countries and shows progress, particularly in LICs and LMICs. WHO has focused its support on these countries and the progress observed also demonstrates a shared political will to monitor and tackle AMR. Countries have also welcomed the shift in approaches to surveillance promoted by GLASS, that is, from those based solely on laboratory data on isolates to systems that include epidemiological, clinical, and population-level data.

13 After application of GLASS cut-off values: AMR data for <10 patients and pathogen–antibiotic combinations for which there are <10 AST results.

The understanding of AMR epidemiology requires a highly synergized approach to data generation *(73)*. To respond to this challenge, GLASS has become a multifaceted system, which integrates key AMR-related surveillance activities aimed at shedding light on the intricate epidemiology of emerging AMR. Among these emerging threats, infections due to AMR fungi and *N. gonorrhoeae* are becoming almost untreatable by available antimicrobials. GLASS-FUNGI aims at addressing the knowledge gap of BSIs caused by *Candida* spp. *(93)*. Apart from collecting data urgently needed to inform the magnitude of the problem globally, GLASS-FUNGI will help inform the work started in 2020 by WHO on identifying priority fungal pathogens, which will be crucial to inform the research and development agenda *(94)*. Data on AMR *N. gonorrhoeae* obtained through routine surveillance are already reported to GLASS-AMR. To complement this surveillance, EGASP is collecting detailed epidemiological data on the drivers involved in the spread of AMR *N. gonorrhoeae*. The bacterium has shown a remarkable capacity for adaptation and has become resistant to all antimicrobials introduced over the past century for gonococcal therapy *(95)*. Currently, ceftriaxone, a last-resort drug, is already first-line therapy recommended for *N. gonorrhoeae* in many countries. However, resistance levels against ceftriaxone are rising globally and incidences of confirmed treatment failure are increasingly encountered *(95)* and more information is needed to adequately plan control actions.

Special surveillance approaches are also needed to generate reliable data on the AMR burden, essential to inform countries' AMR policies and resource allocation *(73)*. With the publication of the "GLASS method for estimating attributable mortality of AMR bloodstream infections", GLASS has initiated the needed generation of evidence to inform on the AMR health impact *(74)*. This new methodology offers a great opportunity for countries to carry out the estimation of AMR attributable mortality using a standardized and robust epidemiological approach that will facilitate the comparability and pooling of estimates at the global level. Moreover, the assessment of the AMR burden of disease will be key to leverage investment to accelerate actions to tackle AMR.

Additionally, GLASS is also fostering increased laboratory capacity in countries to promote rapid and accurate testing, which will significantly impact on global AMR surveillance and diagnostic stewardship. GLASS is encouraging the application of molecular methods, including whole genome sequencing, to support AMR surveillance and to provide information on the early emergence and spread of AMR and further inform research and development efforts. Sequencing data emanating from AMR surveillance may provide vital information to guide the development of rapid diagnostic tools for an improved and more rapid characterization of AMR and thus complement phenotypic methods. WHO recognizes that it needs to support countries to design and establish functional country-specific AMR laboratory networks, with rational positioning of new diagnostic tools at different levels of the health system.

For many years, TB, HIV and malaria programmes have been working to address the challenge of AMR by supporting national and global surveillance networks, strengthening laboratory networks, optimizing diagnostic testing and treatment, raising awareness of the dangers of AMR, and working with stakeholders to innovate products and service delivery *(12)*. Together with WHO Regional Offices, their continuous input and vast number of activities aimed at understanding and controlling AMR provide a massive support to countries and valuable guidance to GLASS development.

While GLASS has made notable achievements in promoting national AMR surveillance systems and sharing data according to global standards, the limitations and gaps in the system still need to be addressed. Technical consideration and limitations linked to AMR surveillance are summarized in detail in Annex 4 and in previous GLASS reports *(18, 96, 97)*.

Countries are at different stages of the development of their national AMR and AMU surveillance systems. Among the limitations observed in reported data from many countries, improving data completeness and national representativeness require special attention. Representativeness may be heavily impacted by a reliance on convenience sampling, especially when the sampling of patient specimens does not follow a systematic approach. Another major constraint to GLASS data is the fact that countries report data aggregated at national level, which limits options for epidemiological characterization and prevents the analysis of the frequency of resistance to multiple antimicrobials. This latter limitation can negatively impact on global efforts directed towards the research and development of new antimicrobial medicines and diagnostics.

Despite the limitations, GLASS has gathered a massive amount of information regarding the antimicrobial susceptibility profile in more than 7 million infections caused by pathogens under surveillance in patients all over the world in only four rounds of data calls. Reporting to GLASS is as important as AMR data collection and has fostered countries' capacity to generate the required information to enable a better analysis and prediction of AMR trends *(98, 99)*.

5.1 The way forward

GLASS has had an undeniable positive impact on AMR surveillance globally. Importantly, the data limitations acknowledged in this report must be addressed. Lessons learnt from the early implementation phase of GLASS (2015–2019) have informed the development of a new version of the GLASS-AMR manual. More pathogens and specimens for selected infection sites have been added and several new antimicrobials have been included to describe resistance to the newly-added target pathogens, including both first- and second-line antimicrobials according to the WHO AWaRe antibiotic categorization *(31)*. Protocols to help countries strengthen routine surveillance precision and representativeness and understand the magnitude of intrinsic bias are being developed. An option for the submission of individual patient-level data has also been included, thus providing additional opportunities for AMR surveillance data validation and analysis, reporting of MDR profiles, and integration with other data types (for example, AMU).

GLASS is also moving towards the application of population-based studies (for example, repeated surveys), particularly for countries where testing coverage is low and routine surveillance results might be of limited value for public health decision making. These surveys are required to ensure that testing is systematic among randomly sampled individuals in a geographic area so that measurements are valid. Furthermore, other surveillance approaches, together with data collected by periodical prevalence surveys, can be implemented to fill some of the remaining gaps. For these surveillance approaches, including syndrome-based surveillance (or case-based), risk-based surveillance, and population-based surveillance using lot quality assurance sampling, GLASS will propose implementation based on countries' needs and constraints and the specific objectives to be reached *(100-102)*.

Surveys such as PPS-AMU and the surveillance of AMC at hospital-level, together with data submitted in an individual-level format, will magnify GLASS analytical capacity to assess the association of antimicrobial use practices and AMR. AMC data collected by routine surveillance can also be used for several other purposes. For example, to raise awareness of appropriate use, inform policy and regulatory changes to optimize use, identify areas for improvement and monitor the impact of interventions, and to improve the procurement and supply of medicines.

GLASS work on the AMR burden is also progressing. An expert consultation on AMR burden will take place in the second part of 2021. Given the urgent need to support the process of implementation of the GLASS method for AMR attributable mortality estimates, an expert network will be established during the second quarter of 2021. The network will be first focusing on the application of the surveys in selected countries. Thus, data collected will enable the calculation of attributable mortality for BSI caused by selected types of AMR (that is, resistant *E. coli* and *S. aureus* at a minimum) in accordance with the GLASS method *(74)*.

Advocacy, communication, and education are essential to engage and support countries, as much as the commitment of Member States and collaboration with partners in AMR surveillance and capacity-building. GLASS benefits from the expertise of the GLASS AMR Collaborative Platform, which comprises the WHO AMR Surveillance and Quality Assessment Collaborating Centres Network and partner technical institutions *(103)*. These groups provide immense technical support to the many activities of GLASS, including the ongoing development of new tools and country capacity building. The regional AMR and AMC surveillance networks and Regional Office-related activities represent important pillars for advancing AMR surveillance globally and play a key role in promoting peer support for capacity building and identifying ways to overcome difficulties.

GLASS calls for and fosters the harmonization of approaches. Yet, there is still a limited understanding of the proposed surveillance standards and the data requirements for informing actions in countries and globally. The new "WHO Academy" has created a unique opportunity to help fill this gap *(104)*. The Academy is a state-of-the-art training institution that aims to bring the lifelong learning revolution to the health sector and reach 10 million learners around the world by 2023. Under the WHO Academy auspices, GLASS is developing a first ever comprehensive training on AMR and AMU surveillance, targeting both policymakers and professionals conducting surveillance activities at all levels. The new course package will be launched in all UN languages in 2022.

A central feature of GLASS continues to be the full ownership of data by countries and their active participation in ensuring the development of national AMR surveillance systems to meet national public health needs. The revision of GLASS, including the method for data collection and reporting, has been presented at the *3rd High-level Technical Consultation and Meeting on Surveillance of Antimicrobial Resistance and Use for Concerted Actions* in April 2021 after a fruitful six-month online consultation led WHO Regional Offices with representatives from countries and other key stakeholders *(22)*. This comprehensive consultation will ensure that the results fully reflect the ideas and the needs of the major players involved in AMR control at national, regional, and global level.

GLASS continues its path to improving the monitoring of global AMR trends and to identifying drivers of AMR. WHO seeks the consolidation of this system to enhance the knowledge and evidence base to inform effective and sustainable control strategies. Lessons learnt and an experience of good practices in preventing and managing AMR are the inspirations driving GLASS development and denote the uniquely strong position of WHO in guiding and coordinating action to tackle AMR globally.

REFERENCES

References

1. O'Neill J. Tackling drug-resistant infections globally: final report and recommendations. In: Review on Antimicrobial Resistance. 2016
2. Antimicrobial resistance factsheet. Geneva: World Health Organization; 2016 (http://www.who.int/mediacentre/factsheets/fs194/en/, accessed 08/04/2021
3. WHO. Antimicrobial resistance: Global Report on Surveillance. Geneva: World Health Organization; 2014 (http://apps.who.int/iris/bitstream/10665/112642/1/9789241564748_eng.pdf?ua=1, accessed 08/04/2021
4. WHO. Global Action Plan on Antimicrobial Resistance. 2015 (http://apps.who.int/iris/bitstream/10665/193736/1/9789241509763_eng.pdf?ua=1, accessed 08/04/2021
5. WHO. Thirteenth General Programme of Work, 2019–2023. Geneva: World Health Organization; 2019 (https://apps.who.int/iris/bitstream/handle/10665/324775/WHO-PRP-18.1-eng.pdf, accessed 08/04/2021
6. UN. Proposals for Consideration in the Open Consultation for the 2020 Comprehensive Review. 2019 (https://unstats.un.org/sdgs/files/ope-consultation-comp-rev/Proposals in Open Consultation for 2020 Review.pdf, accessed 08/04/2021 08/04/2021
7. WHO. Antimicrobial resistance. (https://www.who.int/health-topics/antimicrobial-resistance, accessed 08/04/2021
8. FAO/OIE/WHO. Memorandum of Understanding - Regarding cooperation to combat health risk at the animal-human-ecosystem interface in the context of the "One-Health" approach and including antimicrobial resistance. 2018 (https://www.who.int/zoonoses/MoU-Tripartite-May-2018.pdf?ua=1, accessed 08/04/2021
9. WHO. Global Leaders Group on Antimicrobial Resistance. 2020 (https://www.who.int/groups/one-health-global-leaders-group-on-antimicrobial-resistance, accessed 08/04/2021
10. WHO. Global monitoring of country progress on addressing antimicrobial resistance: Self-assessment questionnaire 2019-2020. 2020 (https://www.who.int/antimicrobial-resistance/global-action-plan/monitoring-evaluation/AMR-country-self-assessment-2019/en/, accessed 08/04/2021
11. FAO/OIE/WHO. Monitoring and evaluation of the global action plan on antimicrobial resistance. Geneva: World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE); 2019 (https://apps.who.int/iris/handle/10665/325006.
12. WHO. Tuberculosis, HIV, malaria and neglected tropical diseases. Strengthening collaboration to prevent and manage antimicrobial resistance. 2019 (https://apps.who.int/iris/bitstream/handle/10665/311689/9789241515450-eng.pdf?ua=1, accessed 08/04/2021
13. ECDC. European Antimicrobial Resistance Surveillance Network (Ears-Net). (https://ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/ears-net, accessed 08/04/2021
14. WHO. Central Asian and Eastern European Surveillance of Antimicrobial Resistance (CAESAR). (http://www.euro.who.int/en/health-topics/disease-prevention/antimicrobial-resistance/about-amr/central-asian-and-eastern-european-surveillance-of-antimicrobial-resistance-caesar, accessed 08/04/2021
15. WHO-AMR/PAHO W. ReLavra: Rede Latinoamericana de Vigilancia de la Resistencia a los Antimicrobianos. (https://www3.paho.org/hq/index.php?option=com_content&view=article&id=13682:relavra-home&Itemid=42427&lang=en, accessed 08/04/2021
16. WHO. GLASS Technical meeting on the early implementation phase, 22-23 October 2015. 2015 (http://www.who.int/antimicrobial-resistance/events/GLASSmeeting/en/.
17. World Health Assembly. Resolution WHA68.7 Antimicrobial Resistance. 2015 (http://apps.who.int/gb/ebwha/pdf_files/WHA68/A68_7-en.pdf.
18. WHO. Global antimicrobial resistance and use surveillance system (GLASS) report Early implementation 2020. 2020 (https://apps.who.int/iris/bitstream/handle/10665/332081/9789240005587-eng.pdf, accessed 08/04/2021
19. WHO. GLASS whole-genome sequencing for surveillance of antimicrobial resistance. 2020 (https://cms.who.int/publications/i/item/9789240011007, accessed 08/04/2021
20. WHO. GLASS guidance for national reference laboratories. 2020 (https://cms.who.int/publications/i/item/9789240010581, accessed 08/04/2021
21. WHO. GLASS Manual for Early Implementation. 2015 (http://apps.who.int/iris/bitstream/10665/188783/1/9789241549400_eng.pdf, accessed 08/04/2021
22. WHO. 3rd High level technical consultation and meeting on surveillance of antimicrobial resistance and use for concerted actions. 2020 (https://www.who.int/news-room/articles-detail/3rd-member-states-technical-consultation-on-surveillance-of-amr, accessed 08/04/2021
23. Seale AC, Gordon NC, Islam J, Peacock SJ, Scott JAG. AMR Surveillance in low and middle-income settings - A roadmap for participation in the Global Antimicrobial Surveillance System (GLASS). Wellcome Open Res. 2017;2:92. doi: 10.12688/wellcomeopenres.12527.1.
24. Ashley EA, Recht J, Chua A, Dance D, Dhorda M, Thomas NV et al. An inventory of supranational antimicrobial resistance surveillance networks involving low- and middle-income countries since 2000. J Antimicrob Chemother. 2018;73:1737-49. doi: 10.1093/jac/dky026.

25. FAO/OIE/WHO. UN Interagency Coordination Group on Antimicrobial Resistance (IACG). 2018 (http://www.who.int/antimicrobial-resistance/interagency-coordination-group/en/, accessed 08/04/2021
26. Public Health Agency of Sweden. NorthernGLASS. 2018 (https://www.folkhalsomyndigheten.se/contentassets/a1e0d7c8f6e4480ea85fba64f0ff2ff7/northernglass-18020.pdf, accessed 08/04/2021
27. WHO. WHO report on surveillance of antibiotic consumption:2016-2018 early implementation. 2018 (http://www.who.int/medicines/areas/rational_use/who-amr-amc-report-20181109.pdf?ua=1, accessed 08/04/2021
28. ECDC. European Surveillance of Antimicrobial Consumption Network (ESAC-Net). (https://www.ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/esac-net, accessed 08/04/2021
29. WHO-EURO. Surveillance of antimicrobial consumption (AMC). (https://www.euro.who.int/en/health-topics/disease-prevention/antimicrobial-resistance/surveillance/antimicrobial-medicines-consumption, accessed 08/04/2021
30. WHO. GLASS methodology for surveillance of national antimicrobial consumption. 2020 (https://www.who.int/publications/i/item/9789240012.
31. WHO. AWaRe. 2019 (https://adoptaware.org/, accessed 08/04/2021
32. WHO. Defined Daily Dose (DDD). (http://www.who.int/medicines/regulation/medicines-safety/toolkit_ddd/en/.
33. WHO. GLASS guide for national surveillance systems for monitoring antimicrobial consumption in hospitals. 2020 (https://apps.who.int/iris/handle/10665/336182, accessed 08/04/2021
34. WHO. WHO Methodology for point prevalence survey on antibiotic use in hospitals. 2018, accessed 08/04/2021
35. WHO. GLASS manual on the management of antimicrobial consumption data. 2020 (https://apps.who.int/iris/handle/10665/336216, accessed 08/04/2021
36. Bank TW. World Bank Country and Lending Groups. 2020 (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups, accessed 08/04/2021
37. EUCAST. EUCAST guidelines for detection of resistance mechanisms and specific resistances of clinical and/or epidemiological importance. [https://eucast.org/]
38. CLSI. M100 Performance Standards for Antimicrobial Susceptibility Testing. [https://clsi.org]
39. Hattori H, Maeda M, Nagatomo Y, Takuma T, Niki Y, Naito Y et al. Epidemiology and risk factors for mortality in bloodstream infections: A single-center retrospective study in Japan. Am J Infect Control. 2018;46:e75-e9. doi: 10.1016/j.ajic.2018.06.019.
40. Sawatwong P, Sapchookul P, Whistler T, Gregory CJ, Sangwichian O, Makprasert S et al. High Burden of Extended-Spectrum β-Lactamase-Producing. Am J Trop Med Hyg. 2019;100:943-51. doi: 10.4269/ajtmh.18-0394.
41. Bevan ER, Jones AM, Hawkey PM. Global epidemiology of CTX-M β-lactamases: temporal and geographical shifts in genotype. J Antimicrob Chemother. 2017;72:2145-55. doi: 10.1093/jac/dkx146.
42. Li Z, Zhuang H, Wang G, Wang H, Dong Y. Prevalence, predictors, and mortality of bloodstream infections due to methicillin-resistant Staphylococcus aureus in patients with malignancy: systemic review and meta-analysis. BMC Infect Dis. 2021;21:74. doi: 10.1186/s12879-021-05763-y.
43. Falagas ME, Karageorgopoulos DE, Leptidis J, Korbila IP. MRSA in Africa: filling the global map of antimicrobial resistance. PLoS One. 2013;8:e68024. doi: 10.1371/journal.pone.0068024.
44. Chopra T, Marchaim D, Awali RA, Krishna A, Johnson P, Tansek R et al. Epidemiology of bloodstream infections caused by Acinetobacter baumannii and impact of drug resistance to both carbapenems and ampicillin-sulbactam on clinical outcomes. Antimicrob Agents Chemother. 2013;57:6270-5. doi: 10.1128/AAC.01520-13.
45. Tahbaz SV, Azimi L, Lari AR. Characterization of aminoglycoside resistance mechanisms in Acinetobacter Baumannii isolates from burn wound colonization. Ann Burns Fire Disasters. 2019;32:115-21.
46. Vijayakumar S, Biswas I, Veeraraghavan B. Accurate identification of clinically important. Future Sci OA. 2019;5:FSO395. doi: 10.2144/fsoa-2018-0127.
47. Elshamy AA, Aboshanab KM. A review on bacterial resistance to carbapenems: epidemiology, detection and treatment options. Future Sci OA. 2020;6:FSO438. doi: 10.2144/fsoa-2019-0098.
48. CDC. Antibiotic Resistance Threats in the United States, 2019. 2019 (https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf, accessed 08/04/2021
49. Bassetti M, Peghin M. How to manage KPC infections. Ther Adv Infect Dis. 2020;7:2049936120912049. doi: 10.1177/2049936120912049.
50. Manchado Fonseca F, Ferreira Paim K. A present and global threat called Extended-Spectrum Beta-lactamases (ESBLs). Current Trends on Biotechnology & Microbiology 2018;1. doi: *10.32474/CTBM.2018.01.000103*.
51. Sallam M, Abbadi J, Natsheh A, Ababneh NA, Mahafzah A, Özkaya Şahin G. Trends in Antimicrobial Drug Resistance of *Streptococcus pneumoniae* Isolates at Jordan University Hospital (2000–2018). Antibiotics (Basel). 2019;8. doi: 10.3390/antibiotics8020041.
52. van de Beek D, Cabellos C, Dzupova O, Esposito S, Klein M, Kloek AT et al. ESCMID guideline: diagnosis and treatment of acute bacterial meningitis. Clin Microbiol Infect. 2016;22 Suppl 3:S37-62. doi: 10.1016/j.cmi.2016.01.007.
53. Gouveia EL, Reis JN, Flannery B, Cordeiro SM, Lima JB, Pinheiro RM et al. Clinical outcome of pneumococcal meningitis during the emergence of pencillin-resistant Streptococcus pneumoniae: an observational study. BMC Infect Dis. 2011;11:323. doi: 10.1186/1471-2334-11-323.
54. WHO. Essential Medicines List (EML) - Handbook (*Unpublished manuscript*). 2021.
55. Liñares J, Ardanuy C, Pallares R, Fenoll A. Changes in antimicrobial resistance, serotypes and genotypes in Streptococcus pneumoniae over a 30-year period. Clin Microbiol Infect. 2010;16:402-10. doi: 10.1111/j.1469-0691.2010.03182.x.

56. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392:1789-858. doi: 10.1016/S0140-6736(18)32279-7.

57. Schaeffer AJ. The expanding role of fluoroquinolones. Dis Mon. 2003;49:129-47. doi: 10.1067/mda.2003.12.

58. Fasugba O, Gardner A, Mitchell BG, Mnatzaganian G. Ciprofloxacin resistance in community- and hospital-acquired Escherichia coli urinary tract infections: a systematic review and meta-analysis of observational studies. BMC Infect Dis. 2015;15:545. doi: 10.1186/s12879-015-1282-4.

59. Khalil IA, Troeger C, Blacker BF, Rao PC, Brown A, Atherly DE et al. Morbidity and mortality due to shigella and enterotoxigenic Escherichia coli diarrhoea: the Global Burden of Disease Study 1990-2016. Lancet Infect Dis. 2018;18:1229-40. doi: 10.1016/S1473-3099(18)30475-4.

60. WHO. Global action plan to control the spread and impact of antimicrobial resistance in Neisseria gonorrhoeae. 2012 (https://apps.who.int/iris/bitstream/handle/10665/44863/9789241503501_eng.pdf?sequence=1, accessed 08/04/2021

61. Unemo M, Lahra MM, Cole M, Galarza P, Ndowa F, Martin I et al. World Health Organization Global Gonococcal Antimicrobial Surveillance Program (WHO GASP): review of new data and evidence to inform international collaborative actions and research efforts. Sex Health. 2019;16:412-25. doi: 10.1071/SH19023.

62. WHO. WHO guidelines for the treatment of *Neisseria gonorrhoeae*. 2016 (http://www.who.int/reproductivehealth/publications/rtis/gonorrhoea-treatment-guidelines/en/, accessed 08/04/2021

63. Riou J, Althaus C, Low N. Modelling study of WHO policy to change treatment recommendations for gonorrhoea when proportion of resistance to first line antibiotic reaches 5%. 2019.

64. Raw Data Resource. Assessing delays to introducing second-line antimicrobials for the control of resistant gonorrhoea using an individual based model. 2019.

65. WHO. Emerging antimicrobial resistance reporting framework. 2018 (https://apps.who.int/iris/bitstream/handle/10665/274956/9789241514590-eng.pdf?ua=1], accessed 08/04/2021

66. WHO. International Health Regulations (2005). Third Edition. 2016 (http://www.who.int/ihr/publications/9789241580496/en/, accessed 08/04/2021

67. WHO. Emerging antimicrobial resistance reporting: Guide for emerging AMR event sharing. 2018 (http://www.who.int/glass/resources/publications/guide-for-emerging-amr-event-sharing/en/, accessed 08/04/2021

68. Webb BJ, Ferraro JP, Rea S, Kaufusi S, Goodman BE, Spalding J. Epidemiology and Clinical Features of Invasive Fungal Infection in a US Health Care Network. Open Forum Infect Dis. 2018;5:ofy187. doi: 10.1093/ofid/ofy187.

69. WHO. GLASS Early implementation protocol for inclusion of Candida spp. 2019 (https://apps.who.int/iris/bitstream/handle/10665/326926/WHO-WSI-AMR-2019.4-eng.pdf?ua=1, accessed 08/04/2021

70. The ESBL tricycle AMR surveillance project: a simple, one health approach to global surveillance. 2017 (http://resistancecontrol.info/2017/the-esbl-tricycle-amr-surveillance-project-a-simple-one-health-approach-to-global-surveillance/, accessed 08/04/2021

71. WHO. WHO integrated global surveillance on ESBL-producing E. coli using a "One Health" approach. 2021 (https://www.who.int/publications/i/item/who-integrated-global-surveillance-on-esbl-producing-e.-coli-using-a-one-health-approach, accessed 08/04/2021

72. WHO. Global surveillance network for gonococcal antimicrobial susceptibility. 1990 (http://apps.who.int/medicinedocs/documents/s16348e/s16348e.pdf.

73. Dunachie SJ, Day NP, Dolecek C. The challenges of estimating the human global burden of disease of antimicrobial resistant bacteria. Curr Opin Microbiol. 2020;57:95-101. doi: 10.1016/j.mib.2020.09.013.

74. WHO. GLASS method for estimating attributable mortality of antimicrobial resistant bloodstream infections. 2020 (https://www.who.int/publications/i/item/9789240000650, accessed 08/04/2021

75. Turner P, Ashley EA, Celhay OJ, Douangnouvong A, Hamers RL, Ling CL et al. ACORN (A Clinically-Oriented Antimicrobial Resistance Surveillance Network): a pilot protocol for case based antimicrobial resistance surveillance. Wellcome Open Res. 2020;5:13. doi: 10.12688/wellcomeopenres.15681.2.

76. WHO. Global action plan on HIV drug resistance 2017–2021. 2017 (https://apps.who.int/iris/bitstream/handle/10665/44863/9789241503501_eng.pdf?sequence=1, accessed 08/04/2021

77. Surveillance of HIV drug resistance in adults receiving ART (acquired HIV drug resistance). Geneva: World Health Organization; 2014: 52.

78. Surveillance of HIV drug resistance in children newly diagnosed with HIV by early infant diagnosis. Geneva: World Health Organization; 2017: 26.

79. Surveillance of HIV drug resistance in populations initiating antiretroviral therapy (pre-treatment HIV drug resistance). Geneva: World Health Organization; 2014: 36.

80. HIV drug resistance surveillance in countries scaling up pre-exposure prophylaxis. Geneva: World Health Organization; 2020.

81. WHO HIVResNet HIV drug resistance laboratory operational framework. Geneva: World Health Organization; 2020: 82.

82. WHO manual for HIV drug resistance testing using dried blood spot specimens. Geneva: World Health Organization; 2020.

83. WHO HIV drug resistance database [Internet]. World Health Organization; 2017 (https://www.who.int/teams/global-hiv-hepatitis-and-stis-programmes/hiv/treatment/hiv-drug-resistance/hiv-drug-resistance-surveillance, accessed 08/04/2021

84. HIV drug resistance report 2019. Geneva: World Health Organization; 2019: 68 (https://www.who.int/hiv/pub/drugresistance/hivdr-report-2019/en/.

85. WHO. Global Tuberculosis Report 2020. 2020 (https://www.who.int/publications/i/item/9789240013131, accessed 08/04/2021

86. WHO. Report on antimalarial drug efficacy, resistance and response: 10 years of surveillance (2010-2019). 2020 (https://www.who.int/publications/i/item/9789240012813, accessed 08/04/2021

87. FAO. The FAO Action Plan on Antimicrobial Resistance 2016-2020. 2016 (http://www.fao.org/3/a-i5996e.pdf, accessed 08/04/2021

88. FAO/OIE/WHO. Technical brief on water, sanitation, hygiene (WASH) and wastewater management to prevent infections and reduce the spread of antimicrobial resistance (AMR). 2020 (https://www.who.int/publications/i/item/9789240006416, accessed 08/04/2021

89. WHO. Strengthening AMR Surveillance in the Region and connecting to GLASS through enhanced Surveillance in blood stream infections 2019 (https://www.paho.org/en/file/58585/download?token=df8xtwMN, accessed 08/04/2021 08/04/2021

90. WHO. AMR/PAHO. ReLAVRA Data Visualization Dashboards. 2019 (https://www3.paho.org/hq/index.php?option=com_content&view=article&id=15319:amr-dashboard-description&Itemid=40388&lang=en).

91. United Nations DoEaSA, Population Division. World Population Prospects: The 2019 Revision. 2019 (https://population.un.org/wpp/, accessed 08/04/2021 08/04/2021

92. WHO. 2019 antibacterial agents in clinical development: an analysis of the antibacterial clinical development pipeline. 2019 (https://www.who.int/publications/i/item/9789240000193, accessed 08/04/2021

93. Rodrigues ML, Nosanchuk JD. Fungal diseases as neglected pathogens: A wake-up call to public health officials. PLoS Negl Trop Dis. 2020;14:e0007964. doi: 10.1371/journal.pntd.0007964.

94. WHO. First meeting of the WHO antifungal expert group on identifying priority fungal pathogens. 2020 (https://www.who.int/publications/i/item/9789240006355, accessed 08/04/2021

95. Yang F, Yang J. Antibiotic Resistance and Treatment Options for Multidrug-Resistant Gonorrhea. Infectious Microbes & Diseases. June 2020;2:67-76. doi: 10.1097/IM9.0000000000000024.

96. WHO. Global Antimicrobial Resistance Surveillance System (GLASS) Report: early implementation 2016-2017. 2018 (http://www.who.int/glass/resources/publications/early-implementation-report/en/, accessed 08/04/2021

97. WHO. Global Antimicrobial Resistance Surveillance System (GLASS) Report: early implementation 2017-2018 2019 (https://www.who.int/glass/resources/publications/early-implementation-report-2017-2018/en/.

98. Omulo S, Thumbi SM, Njenga MK, Call DR. A review of 40 years of enteric antimicrobial resistance research in Eastern Africa: what can be done better? Antimicrob Resist Infect Control. 2015;4:1. doi: 10.1186/s13756-014-0041-4.

99. Woolhouse M, Waugh C, Perry MR, Nair H. Global disease burden due to antibiotic resistance - state of the evidence. J Glob Health. 2016;6:010306. doi: 10.7189/jogh.06.010306.

100. Ryu S, Cowling BJ, Wu P, Olesen S, Fraser C, Sun DS et al. Case-based surveillance of antimicrobial resistance with full susceptibility profiles. JAC Antimicrob Resist. 2019;1:dlz070. doi: 10.1093/jacamr/dlz070.

101. Ginting F, Sugianli AK, Bijl G, Saragih RH, Kusumawati RL, Parwati I et al. Rethinking Antimicrobial Resistance Surveillance: A Role for Lot Quality Assurance Sampling. Am J Epidemiol. 2019;188:734-42. doi: 10.1093/aje/kwy276.

102. Stärk KD, Regula G, Hernandez J, Knopf L, Fuchs K, Morris RS et al. Concepts for risk-based surveillance in the field of veterinary medicine and veterinary public health: review of current approaches. BMC Health Serv Res. 2006;6:20. doi: 10.1186/1472-6963-6-20.

103. WHO. WHO AMR Surveillance and Quality Assessment Collaborating Centres Network. (https://www.who.int/glass/collaborating-centres-network/en/, accessed 08/04/2021.

104. WHO. WHO Academy. (https://www.who.int/about/who-academy, accessed 08/04/2021

105. WHO. WHO Model List of Essential Medicines. 2019 (https://apps.who.int/iris/bitstream/handle/10665/325771/WHO-MVP-EMP-IAU-2019.06-eng.pdf?ua=1, accessed 08/04/2021

106. Gaynes R. Surveillance of antibiotic resistance: learning to live with bias. Infect Control Hosp Epidemiol. 1995;16:623-6. doi: 10.1086/647025.

107. Thacker SB, Parrish RG, Trowbridge FL. A method for evaluating systems of epidemiological surveillance. In: World Health Statistics Quarterly. 1988 (https://apps.who.int/iris/handle/10665/46624, accessed 08/04/2021 08/04/2021

108. WHO. Guidelines for surveillance of drug resistance in tuberculosis. 2015 (http://apps.who.int/iris/bitstream/handle/10665/174897/9789241549134_eng.pdf, accessed 08/04/2021

109. Burger RP, McLaren ZM. An econometric method for estimating population parameters from non-random samples: An application to clinical case finding. Health Econ. 2017;26:1110-22. doi: 10.1002/hec.3547.

110. Hanson CL, Osberg M, Brown J, Durham G, Chin DP. Conducting Patient-Pathway Analysis to Inform Programming of Tuberculosis Services: Methods. J Infect Dis. 2017;216:S679-S85. doi: 10.1093/infdis/jix387.

111. WHO. GLASS Guide to uploading of aggregated antimicrobial resistance data. 2015 (http://apps.who.int/iris/bitstream/10665/251740/1/WHO-DGO-AMR-2016.7-eng.pdf, accessed 08/04/2021

ANNEXES

Annex 1. GLASS-AMC international classification and categorization system

The ATC/DDD system is a well-established international system used as the basis for the classification of medicines and the calculation of medicines consumption estimates. The system is maintained by the WHO Collaborating Centre for Drug Statistics Methodology and is updated annually[14].

The ATC classification is the most commonly used method for aggregation of medicines data, and it allows flexibility in reporting by medicine or groups of medicines. Active substances are classified in groups at five different levels according to the organ or system on which they act, and their therapeutic, pharmacological, and chemical properties. The DDD is the assumed average maintenance dose per day for a medicine used for its main indication in adults *(32)*. A DDD is only assigned for drugs that already have an ATC code. The DDD is a technical unit to measure the use; it does not necessarily reflect the recommended or average prescribed dose. The DDDs for the anti-infectives are generally based on use in infections of moderate severity. However, some anti-infectives are only used in severe infections and their DDDs are assigned accordingly. To adjust for population size, the consumption is usually presented as the number of DDDs per 1000 inhabitants per day. This metric can be roughly interpreted as the number of individuals per 1000 inhabitants on antibiotic treatment per day.

14 https://www.who.int/tools/atc-ddd-toolkit/methodology

Annex 2. AWaRE categorization

As part of the 2017 essential medicines list, WHO introduced a new categorization of antibiotics to guide prescriptions and treatment – AWaRe – and this has been updated in 2019 *(31, 105)*. The AWaRe categorization is based on a methodological approach that takes into consideration the treatment guidelines of the most frequent infectious disease syndromes. The Access group contains antibiotics intended to be used as first- and second-choice therapy. These antibiotics should be consistently available in an appropriate quality and for an affordable price in every country. The Watch group includes mainly broad-spectrum antibiotics, which, because of their higher potential to induce the development of resistance or their unfavourable benefit–risk balance (or both), should only be used for specific indications. The Reserve group represents last resort antibiotics that should only be used if other antibiotics do not work anymore.

The AWaRe categorization is intended for application as a tool for antimicrobial stewardship purposes to assist countries in their efforts towards optimizing antimicrobial use. The overall goal is to reduce the use of Watch and Reserve group antibiotics, and to increase the relative use and the availability of Access group antibiotics, where needed.

Annex 3. GLASS-AMC data sources

1. **Procurement and supply level**
- import data (using data from customs records and declaration forms)
- production records of domestic manufacturers (excluding any exports of products)
2. **Distribution level**
- wholesaler and distributor data
- public sector procurement records
- donations or programmes – this may relate to specific international health programmes (for example, for HIV, TB, or malaria), or to particular populations who may receive medicines from non-governmental organizations (NGOs), such as migrants and refugees.
3. **Dispensing level**
- records from community and hospital pharmacies, and licensed drug stores
- data from health insurance programmes
4. **Prescribing level**
- prescribing records of doctors and dispensing records of pharmacists
5. **Patient use level**
- information on antimicrobial use from patients themselves.

Annex 4. Readers' guide to GLASS-AMR results

GLASS collects information on the status of national AMR surveillance systems from the answers to a short questionnaire sent annually to AMR national focal points. The questionnaire addresses overall coordination, the surveillance system and quality control, with a set of indicators (Table A.1) to measure development and strengthening of national AMR surveillance. The indicators allow basic understanding of the structure of the surveillance systems that collect the AMR results reported to GLASS and help in identifying both the strengths and capacity of enrolled countries and any challenges and limitations for making representative estimates of AMR.

Table A.1. GLASS indicators of national surveillance

AREA	INDICATOR	OUTCOME
Coordination	Existence of a plan for a functioning national AMR surveillance	Exists, with budget/Exists without budget/Does not exist/Unknown
	Establishment of a national coordinating centre	Established/Not established/ Unknown
	Nomination of an NRL	Established/Not established/ Unknown
Surveillance system	Total number of AMR surveillance sites (hospital and outpatient facilities) that send data to GLASS	Numerical
	Number of local clinical laboratories that perform AST and send data to GLASS	Numerical
Quality assessment	EQA provided for NRL	Provided/Not provided/Unknown
	Type of AST standards followed by countries	CLSI, EUCAST, other
	EQA provided to local laboratories that perform AST for national AMR surveillance sites	To all laboratories/Some laboratories/ Not provided/ Unknown

Indicators of the implementation of surveillance indicators are summarized for each country, by WHO region, in Section 2.2.2., and national results are presented as infographics in the country profiles. The indicators are monitored annually to assess countries' progress.

AMR data are collected through a case-finding surveillance system, which collates results from susceptibility testing of specimens from blood, urine, stool, as well as cervical and urethral specimens, that have been sent routinely to diagnostic laboratories for clinical purposes. The population from which AMR data are collected is the population of patients seeking care in healthcare facilities (HCFs).

GLASS is based on the rationale that the growth of a pathogen in selected specimens is a proxy of infection in the associated anatomical sites (bloodstream, urinary tract, gastro-enteric, genital). Reliable data should represent a single episode of illness in a patient. For microbiological data, only the first positive culture from a patient is reported for each disease episode for surveillance purposes, even if several positive cultures are obtained or resistance emerges during treatment. Therefore, after removal of duplicates and on the assumption that routine microbiological testing is done systematically, the number of isolates for which laboratory AST results can be used represents the number of patients infected with targeted susceptible or resistant bacteria at a specific anatomical site [18]. GLASS uses this information to generate the proportions of infected patients with growth of non-susceptible strains for each specimen type, pathogen, antibiotic under surveillance.

Countries are asked to report epidemiological variables such as age, gender, and origin of infection for tested patients. The origin of infection is used as a proxy of where the infection was contracted (hospital or community) [18]. Population data are also collected for all samples taken for microbiological testing, GLASS records the numbers of patients with positive and negative samples (no microbial growth), which is used as a denominator to generate two additional metrics for each specimen type, pathogen, antibiotic under surveillance in the population of tested patients: frequency of infection and frequency of infection due to non-susceptible strains [18].

GLASS receives submissions of AMR rates not only directly but also through CAESAR and EARS-Net, which are established, official AMR surveillance networks. Both networks collect information on AMR rates in blood specimens for *Acinetobacter* spp., *K. pneumoniae*, *E. coli*, *S. aureus* and *S. pneumoniae*. In order to avoid duplication of data submitted, the countries participating in these networks and enrolled in GLASS may authorize the ECDC for EARS-Net or the WHO Regional Office for Europe for CAESAR to transfer the data to GLASS. These countries also send additional data directly to GLASS.

GLASS accepts submissions of AST results for both single antibiotics and sub-groups of antimicrobials. Results reported by countries to EARS-Net are submitted to GLASS aggregated by antimicrobial class. According to the method for AMR data preparation and analysis used by ECDC, if AST results are reported for more than one antibiotic belonging to the same antimicrobial class (or group) in the same patient, results for only one of the antibiotics are considered. Class susceptibility is calculated after final interpretation of the AST results for each antibiotic: if a pathogen is reported to be resistant (R) to at least one antibiotic, it is considered to be resistant to the whole class; if the result for at least one antibiotic is reported to be in susceptibility category "I", and no resistance is reported to any of the other antibiotics, the whole class is considered to be in category "I"; if the pathogen is reported to be susceptible to at least one antibiotic and neither as R nor I to any of the other antibiotics, it is considered to be susceptible to the whole class.

Annex 5. Considerations regarding AMR surveillance approaches

There is no perfect surveillance system. Nevertheless, this does not disregard the importance and value of the information collected and reported. It is essential to identify and understand the limitations of the system, and to take into account several considerations when interpreting information generated following the GLASS-AMR approach.

Considerations when generating AMR estimates for the target population using data collected through surveillance

In any surveillance model the data collected and reported often will only represent the tip of the iceberg, frequently because of bias associated with the system design. In the case of antimicrobial resistance, the type of bias of greatest concern is selection bias *(106)*. Selection bias leads to a distortion in the estimate of effect (that is, the percentage of isolates of a pathogen that are resistant to an antimicrobial agent) resulting from the way subjects (or isolates) are selected for the study population. For example, often data are collected from a subset of HCFs, located in defined geographical areas (for example, main cities), or representing selected type of care (for example., tertiary hospitals); patients in wards for certain medical specialties might be more likely to be screened for infection caused by resistant bacteria (for example, ICU, surgical wards).

If a surveillance system collects reports on all occurrences of a health event for the target population, then the system is, by definition, representative *(107)*. However, if it is known that health care service coverage of the target population is not comprehensive, selection bias might cause the surveillance system to generate data that will over- or underestimate the true proportion of AMR in the target population, so that obtained AMR rates will not be representative.

GLASS is developing a protocol that describes minimum sampling criteria to be applied by countries when implementing surveillance. This is to assist countries that do not have the comprehensive health care service coverage necessary for the surveillance system to generate representative AMR rates at national and sub- national level for the target population.

Considerations when relying on routine diagnostic data for surveillance purposes

It is important to highlight some of the disadvantages when relying only on diagnostic microbiological results for surveillance, particularly in limited resource countries. These include:

1. Difficulties in obtaining a representative sample of the population seeking care, even when minimum sampling criteria are set.
2. Lack or limited access to health care and microbiological tests could exclude a significant proportion of the population with infectious syndromes that should be under surveillance. This limitation will result in difficulty in obtaining a representative sample of the population with AMR infections.
3. Late microbiological testing can lead to distorted rates. For instance, in settings where microbiological sampling is not performed routinely, many patients may be tested only after antimicrobial treatment failures or when severely ill. This is likely to cause a reporting bias, with an over-estimation of the true resistance burden within that population.
4. Inaccurate microbiological testing will distort the estimation of frequency of AMR which can lead to either over- or underestimation, depending on the direction of the inaccuracy.

To address the first issue, GLASS is developing protocols to help enhance precision and representativeness of routine surveillance. Additionally, other surveillance approaches, together with data collected by periodical prevalence surveys, can be implemented to fulfil some of the remaining gaps *(108, 109)*. These additional surveillance approaches include syndrome-based surveillance, case-based surveillance, and population-based surveillance using Lot Quality Assurance Sampling (LQAS). The application of complementary approaches should be based on countries' needs and constraints, and the objective(s) to be achieved.

Syndrome-based surveillance implies active and systematic case-finding of patients with signs and symptoms that meet the case definitions for the specific syndromes. This approach can more accurately reflect the incidence of resistant infections in the population under surveillance and may provide more precise data about the burden of AMR in the population. At the same time, it is laborious and may require resources that may not be available in many countries.

The basic concept of case-based surveillance is prospective surveillance of a defined population or patient group, aiming to assess the frequency of infections caused by particular pathogens and the prevalence of antimicrobial resistance among identified pathogens. The case-based surveillance requires additional resources compared with sample-based surveillance because of the need for detailed clinical information in addition to the laboratory results. To minimize the additional logistical burden, only a subset of cases could be sampled, for example on certain days of the week in selected sentinel hospitals and clinics *(100)*.

Finally, population-based surveillance using lot quality assurance sampling (LQAS) combines surveillance of individuals in a defined population who present with signs and symptoms that meet the case definitions for the specific syndrome, with a sampling strategy that can minimize logistic constraints. This approach yields a classification of the AMR prevalence as "high" or "low" by setting a proportion of resistance threshold and a sample size that will allow to define if the target population is above or below the threshold: This approach might be sufficient to guide empirical treatment decisions and for estimates of AMR in low morbidity, low mortality infectious syndromes, but it does not accurately measure the real magnitude of AMR in the population *(99)*.

Considerations when targeting the population of patients seeking care

It is paramount to point out that the method described in this document aims at generating AMR estimates for the subset of the national population that seeks and has access to health care and laboratory tests. Self-treatment at home, and treatment at a local pharmacy or drug dispenser, can be very frequent in certain settings, and can be a driver for AMR. Additional studies must be designed and run in parallel to estimate AMR in the proportion of the population that cannot be captured by healthcare facility-based approaches. Community-based surveys, healthcare facility access behaviour surveys and patient-pathway analyses can help to fill this gap in essential information *(110)*.

Considerations for reporting isolate-based vs. sample-based data

Although both isolate-based and sample-based data can be reported to GLASS, GLASS encourages countries to collect and report patients-based data. Isolate-based surveillance only provides data on resistance patterns within the bacterial population, as the information is only collected for patients infected by pathogens under surveillance. Sample-based surveillance can provide insight into patterns and the extent of AMR in the population undergoing testing per specimen types. In settings where patients with suspected infections are systematically tested, the sample-based approach provides a proxy for all patients with the infection under surveillance. For example, using the tested population as the denominator allows estimation of frequency of reported infectious syndromes associated with a resistant pathogen, which can be stratified to identify prevalence of AMR by demographic or epidemiological categories, e.g., by age, gender, hospital, or community infection onset.

Considerations when assuming the clinical significance of reported microbiological data

Some of the isolates identified may possibly represent cases of contamination of a specimen or colonization at a sampled site. The surveillance centre must take responsibility for assessing the clinical significance of positive cultures. However, it is important to be aware when interpreting the data that some patients may have a combination of the bacteria causing infection and colonization because the lab could not differentiate "true pathogens" from "colonizers." This is important to consider, as the number of reported isolates might be higher than those causing infections and therefore also the prevalence of AMR will be overestimated.

Considerations about selective testing for pathogens and antimicrobial combination under surveillance

The AST results for a specific antimicrobial could be missing due to selective testing, including second line/cascade testing when second-line antimicrobials are tested only on isolates resistant to first-line antibiotics, and prescribing-specific testing when testing is limited to those antimicrobials that are requested or currently used for treatment. In addition, some laboratories may selectively report only a subset of the AST results to clinicians e.g., to encourage good antimicrobial stewardship. When selective reporting is applied, surveillance reports should be generated from the full database of results for all antimicrobials that are routinely tested, and not from the selectively reported data.

Annex 6. Reporting activities on antimicrobial resistance, by region, specimen, and pathogen

REPORTED INFECTION BY WHO REGIONS	NUMBER OF COUNTRIES, TERRITORIES AND AREAS REPORTING ON SPECIFIC PATHOGEN							
(n=number of countries, areas, and territories)	*Acinetobacter* spp.	*E. coli*	*K. pneumoniae*	*N. gonorrhoeae*	*Salmonella* spp.	*Shigella* spp.	*S. aureus*	*S. pneumoniae*
Bloodstream								
Africa (n=8)	7	7	7	×	5	×	6	4
Americas (n=2)	2	2	2	×	2	×	2	2
Eastern Mediterranean (n=18)	17	17	16	×	12	×	15	10
European (n=25)[a]	25	25	25	×	10	×	25	23
South-East Asia (n=8)	8	8	8	×	8	×	8	6
Western Pacific (n=9)	9	9	8	×	8	×	8	6
Total	**68**	**68**	**66**	**×**	**45**	**×**	**64**	**51**
Urinary Tract								
Africa (n=8)	×	5	5	×	×	×	×	×
Americas (n=2)	×	2	2	×	×	×	×	×
Eastern Mediterranean (n=18)	×	18	16	×	×	×	×	×
European (n=25)[a]	×	9	9	×	×	×	×	×
South-East Asia (n=8)	×	7	7	×	×	×	×	×
Western Pacific (n=9)	×	6	6	×	×	×	×	×
Total	**×**	**47**	**45**	**×**	**×**	**×**	**×**	**×**
Gastrointestinal								
Africa (n=8)	×	×	×	×	4	4	×	×
Americas (n=2)	×	×	×	×	1	2	×	×
Eastern Mediterranean (n=18)	×	×	×	×	12	11	×	×
European (n=25)[a]	×	×	×	×	8	6	×	×
South-East Asia (n=8)	×	×	×	×	6	5	×	×
Western Pacific (n=9)	×	×	×	×	6	6	×	×
Total	**×**	**×**	**×**	**×**	**37**	**34**	**×**	**×**

REPORTED INFECTION BY WHO REGIONS	NUMBER OF COUNTRIES, TERRITORIES AND AREAS REPORTING ON SPECIFIC PATHOGEN							
(n=number of countries, areas, and territories)	*Acinetobacter spp.*	*E. coli*	*K. pneumoniae*	*N. gonorrhoeae*	*Salmonella* spp.	*Shigella* spp.	*S. aureus*	*S. pneumoniae*
Genital								
Africa (n=8)	×	×	×	3	×	×	×	×
Americas (n=2)	×	×	×	2	×	×	×	×
Eastern Mediterranean (n=18)	×	×	×	8	×	×	×	×
European (n=25)[a]	×	×	×	4	×	×	×	×
South-East Asia (n=8)	×	×	×	3	×	×	×	×
Western Pacific (n=9)	×	×	×	7	×	×	×	×
Total	**×**	**×**	**×**	**27**	**×**	**×**	**×**	**×**

a Kosovo included: all references to Kosovo in this document should be understood in the context of UN Security Council resolution 1244 (1999).

Annex 7. Analysis and interpretation of data on antimicrobial resistance

Reported Data

GLASS requests submission of two types of AMR data files generated from the same source database which are outlined below.

The resistant, intermediate, susceptible "RIS" file **with** susceptibility testing ***results***. These are 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, CLSI, or other national definitions *(37, 38)*. Data includes numbers of patients with susceptible, non-susceptible, intermediate, and resistant isolates, as well as numbers of isolates with unknown susceptibility. Two different types of unknown results are recorded: "Unknown_no_AST" representing the number of isolates with AST results not reported (or not performed) for a specific antibiotic, and "Unknown_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:

- **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), or as unknown.
- **Gender:** female, male, unknown.
- **Infection origin:** hospital, community, unknown. Countries were advised to use the following definition: "Hospital" origin is selected for patients 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. Countries using a different classification method were nevertheless invited to report infection origin data in the GLASS format.

SAMPLE *file* with *the numbers of patients seeking care at surveillance sites*. In hospital and community facilities from which specimens for bacterial isolation were taken over a defined period, stratified by the same variables as in the RIS file.

Data preparation

GLASS requires input data to be de-duplicated, so that one isolate will represent one patient. This minimises bias associated with reporting of repeated cultures. Thus, when several cultures are collected from one patient, repeat isolates of a given species from the same patient are excluded. Only the first isolate per patient, per pathogen, per reporting period, and per stratification level is included. Note that for national and local surveillance, it is important to collect consecutive isolates of the same pathogen in order to monitor clinical episode characteristics. De-duplication and data quality assurance should be performed either at surveillance sites before submission to the NCC, or by the NCC. If deduplication 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 *(111)*) The 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 subsets of national aggregated data. This approach 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, for example by regions.

AMR data validation and analysis

Countries are responsible for ensuring the validity, consistency, and completeness of AMR data submitted to GLASS. A second validation step is performed during the AMR uploading process thanks to a series of automatic checks built into the GLASS platform, which identify issues related to the integrity of the dataset (e.g., variables, codes), and the consistency of the data provided (for example, 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 and R Software.

AMR data are summarised by country, and main results are represented graphically and compiled into tables in the GLASS GHO Page and the report electronic supplementary material in the report 2021 webpage (https://www.who.int/initiatives/glass/resource-centre/#glassreports). AST results are categorised as follows: susceptible, non-susceptible (non-susceptible + intermediate + resistant), and unknown (unknown_no_AST + unkown_no_breakpoints).

Data are described by the following approaches:

1. **Pathogen non-susceptibility overview:** For each specimen type, pathogen and antibiotic under surveillance, the proportions of patients with growth of non-susceptible strains are calculated from the following formula and described graphically:

(Number of patients, per specimen type, with infection by pathogen_x resistant to antibiotic_y under surveillance / Total number of patients, per specimen type, with infection by pathogen_x susceptible, I, and resistant to antibiotic_y under surveillance) *100

Overall AST results, the proportion of samples with unknown AST and AST results stratified by specimen type, age, gender, and origin of infection are provided electronically in the supplementary material in the report 2021 webpage (https://www.who.int/initiatives/glass/resource-centre/#glassreports).

Further analysis is performed for data based on samples. As countries are asked to provide only clinically significant results, reported positive cultures are considered proxies of infection. In addition, data deduplication allows reporting only of new cases. Therefore, the frequency of infection with the pathogens under surveillance and the frequency of infection with pathogens that are not susceptible to specific antibiotics are calculated for the population at risk, defined as the total number of symptomatic patients who sought medical care and from whom a specimen was taken.

2. **Non-susceptible pathogen–antimicrobial combination frequency:** For each specimen type, origin of infection and pathogen, the frequency of patients with infections is calculated per 100 000 tested patients from the following formula and presented graphically:

(Number of patients, per specimen type and infection origin, with infection by pathogen_x under surveillance / Population tested during the reporting period per specimen type and infection origin) *100 000

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

(Number of patients, per specimen type and infection origin, with infection by pathogen_x resistant to antibiotic_y under surveillance / Population tested during the reporting period per specimen type and infection origin) *100 000

The two charts are aligned to show the relation between the size of the contribution of each pathogen to infection at a specific anatomical site and the frequency of infections caused by pathogens resistant to specific antibiotics. The frequencies of AMR are also provided electronically in the supplementary material in the report 2021 webpage (https://www.who.int/initiatives/glass/resource-centre/#glassreports).

3. Meropenem was chosen to illustrate resistance to carbapenems. As indicated by the European Committee on Antimicrobial Susceptibility Testing, meropenem offers the best compromise between sensitivity and specificity in terms of detecting carbapenemase producers. Carbapenem resistance is one of the types of resistance of greatest concern worldwide, and several carbapenem-resistant pathogens are included as critical priorities on the WHO list of priority pathogens *(6)*. When meropenem is not tested, imipenem may be tested instead.

   For each specimen type, pathogen and origin of infection, the frequency of strains non-susceptible to carbapenem is calculated per 100 000 tested patients, stratified by gender and age, from the following formula, and presented graphically:

(Number of patients, per specimen type, age, gender and infection origin with infection by pathogen_x resistant to carbapenems / Population tested during the reporting period per specimen type, age, gender and infection origin) *100 000

All results stratified by age, gender, and origin of infection for all reported antibiotics are provided in the electronic supplementary material in the report 2021 webpage (https://www.who.int/initiatives/glass/resource-centre/#glassreports).

Pathogens isolated in specimens from < 10 patients are excluded from the analysis. The proportions and frequencies of AMR are not shown for pathogen–antibiotic combinations that are not reported, for which there are < 10 AST results or for which 100% of AST results are unknown. If the unknown AST results are more than 30%, in the pathogen non-susceptibility overview graphs of single countries the bars are not coloured and in the non-susceptible pathogen – antimicrobial combination frequency graphs only the antibiotics names are shown, without any graphical representation of the outcomes the 30% rule is not applied to the global summary results. If the proportion of provided information on infection origin and or gender is below 70%, frequency results are not stratified.

Confidence intervals (CIs) are calculated using the Wilson method to address limitations due to small sample sizes or zero values.

Annex 8. Pathogen-antimicrobial combinations under GLASS-AMR 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

PATHOGEN	ANTIBACTERIAL CLASS	ANTIBACTERIAL AGENTS THAT MAY BE USED FOR AST[a,b]
Shigella spp.	Fluoroquinolones	Ciprofloxacin or levofloxacin
	Third-generation cephalosporins	Ceftriaxone, cefotaxime, or ceftazidime
	Macrolides	Azithromycin
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. R, I, S 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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