GLASS guide on use of national data on antimicrobial use

Informing policies and strengthening stewardship efforts

World Health Organization

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Foreword

Antimicrobial resistance (AMR) is a growing global threat that is undermining decades of progress in medicine and public health. As resistant infections become more common, due to inappropriate use of antimicrobials, preserving the effectiveness of existing antimicrobials is increasingly urgent. Central to this effort is monitoring use of antimicrobials in countries, sectors and at different levels of care and translating that knowledge into action to ensure that these invaluable medicines are used appropriately throughout health systems.

This guide reflects the ongoing commitment of the World Health Organization (WHO) to support countries in strengthening surveillance of antimicrobial use (AMU) and using the data to inform national policies for antimicrobial stewardship (AMS). It builds on the Global Antimicrobial Resistance and Use Surveillance System (GLASS), the Access, Watch, Reserve (AWaRe) classification of antibiotics and other key WHO tools and methods that help countries to monitor AMU, set targets and evaluate the impact of AMS. Surveillance of AMU is not merely a technical exercise: it is the basis of effective AMS, strategies to ensure equitable access and evidence-based policy-making. When implemented effectively, AMU surveillance can identify gaps, track progress and guide interventions to improve patient care and contain AMR.

In 2024, global leaders reaffirmed their commitment to tackling AMR during a high-level meeting of the United Nations General Assembly. A key outcome was endorsement of a global target: at least 70% of antibiotics used nationally should be in the Access group, which are antibiotics recommended as first-line treatments for common infections and associated with a lower risk of resistance. Monitoring progress in achieving this target requires robust surveillance systems capable of tracking AMU in all sectors and settings.

Meeting these goals also requires multidisciplinary collaboration. From planning and data collection to interpretation and action, AMU surveillance relies on a number of competencies for measuring use of these medicines, analysing patterns of use and reflecting on the information obtained to inform policy. AMU surveillance also requires contributions by various disciplines, from epidemiology and pharmacy to clinical care, data science and policy. Early, consistent engagement of diverse stakeholders will ensure that surveillance is relevant, actionable and sustainable.

WHO thanks all the contributors and supporters who made this guide possible, reflecting a shared global commitment to safeguarding the effectiveness of antimicrobials. We hope this resource will empower national stakeholders to strengthen surveillance, improve AMU and advance progress toward the goal of 70% Access antimicrobials and broader AMR containment goals.

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Abbreviations

AMR	antimicrobial resistance
AMS	antimicrobial stewardship
AMU	antimicrobial (or antibiotic) use
API	Active Pharmaceutical Ingredient
ATC	Anatomical Therapeutic Chemical (classification system)
AWaRe	Access, Watch and Reserve (classification of antibiotics)
COVID-19	coronavirus disease 2019
DDD	defined daily dose
DHIS2	District Health Information System 2
DID	defined daily dose/1000 inhabitants per day
DU75	75% drug utilization
DU90	90% drug utilization
EML	Essential Medicines List (WHO Model List of Essential Medicines)
FPP	Finished Pharmaceutical Product
GLASS	Global Antimicrobial Resistance and Use Surveillance System
IT	information technology
OTC	over the counter
PPS	point prevalence survey
SEMC	State Essential Medicines Company
WHO	World Health Organization

Glossary

Anatomical Therapeutic Chemical (ATC) classification system: a WHO international classification of all medicines into groups according to the organ or system on which they act and their therapeutic, pharmacological and chemical properties. Medicines are classified into five levels. The ATC system makes it possible to compare medicine use across settings and is the basis for GLASS-AMU surveillance. The ATC system is closely linked to the concept of defined daily dose (DDD), constituting the ATC/DDD methodology. See also DDD.

Antibiotics: antimicrobial medicines (see below) that are active against bacteria. Sometimes, antibiotics are called antibacterials. Although this document addresses antibiotics, most of the principles outlined also apply to other antimicrobials.

Antimicrobial medicines: include antibacterials (usually referred to as antibiotics), antivirals, antifungals and antiparasitics. They are used to prevent and treat infections in humans, animals and plants.

Antimicrobial resistance (AMR): occurs when bacteria, viruses, fungi and parasites change over time so that they do not respond to medicines, making infections more difficult to treat and increasing the risk of disease spread, severe illness and death. As a result of AMR, antimicrobials become ineffective.

Antimicrobial stewardship (AMS): a coherent set of actions at various levels of the health system to promote appropriate use of antimicrobials. It includes policy, programmes and technical support to health-care workers for deciding when to use antimicrobials, which ones to select and the appropriate dosing, route of administration and duration of treatment. Its aim is to optimize AMU as an initiative to improve patient safety and quality of care. When the set of actions specifically targets the appropriate use of antibiotics the term Antibiotic stewardship is also used.

Appropriate use of antimicrobials: antimicrobial use (AMU) in a manner which is consistent with the best available evidence and aligned with the principles of stewardship. It balances adequate prevention and treatment of infections for optimal outcomes with the unintended consequences of AMU, such as adverse effects and the emergence and spread of AMR at both the individual and population level.

AWaRe classification of antibiotics: According to the AWaRe system, antibiotics are classified into one of three categories: Access, Watch or Reserve, to indicate the circumstances for consideration of use. The purpose is to support AMS by guiding appropriate use of antibiotics to contain AMR. The AWaRe classification is updated by WHO every 2 years.

Access antibiotics are generally effective and have a narrow spectrum of activity, lower price, good safety profile and low resistance potential. Essential Access antibiotics are empiric first- or second-choice treatment options for common infections. Examples include amoxicillin, sulfamethoxazole/trimethoprim and gentamicin. WHO recommends that at least 70% of total antibiotic use at national level is from this category.

Watch antibiotics have a broader spectrum and are generally more expensive, with a higher potential for resistance. Essential Watch antibiotics are the first choice for severe clinical presentations and against pathogens that are resistant to Access antibiotics. Examples include azithromycin, ciprofloxacin and ceftriaxone.

Reserve antibiotics are last-resort options for treating infections caused by multidrug-resistant organisms. They should be preserved for severe cases in which other antibiotics are inactive or have failed to minimize the development of resistance. Examples include colistin, ceftazidime/avibactam, cefiderocol and linezolid.

The AWaRe classification also includes a category of antibiotics that are Not recommended. They are excluded from treatment guidelines because of their high potential for causing resistance, lack of efficacy or safety concerns and should be avoided in clinical practice. Examples include many fixed-dose combinations, such as amoxicillin/cloxacillin, ampicillin/flucloxacillin and cefixime/linezolid.

While the AWaRe system began as a classification tool, it now includes several other components:

- the AWaRe antibiotic book, a practical guidance for clinicians on antibiotic use within the AWaRe framework;
- AWaRe quality Indicators, for monitoring and improving the quality of AMU; and
- AWaRe targets, which are global targets, including that endorsed by the United Nations General Assembly for at least 70% of antibiotic use to come from the Access group.

Broad-spectrum antibiotic: There is no universal definition of a broad-spectrum antibiotic. The term is used mainly to distinguish antibiotics that are effective against a wide range of bacteria and have a large impact on the selection and spread of resistance as opposed to antibiotics with a more limited range of activity and less impact on resistance (narrow-spectrum antibiotics). The AWaRe classification replaces the distinction between broad- and narrow-spectrum antibiotics with a standardized, more nuanced classification to guide appropriate use of antibiotics.

Clinical data on AMU: data on AMU that include information on patient and prescriber characteristics, indication and treatment regimens (such as dose, formulation, duration) and therefore enable a more detailed assessment of the appropriateness of AMU. Collection of such data is, however, often time and resource intensive.

Combination product: See Fixed-dose combination.

Defined Daily Dose (DDD): the assumed average maintenance dose per day for a medicine used for its main indication in adults. DDD is part of the WHO ATC/DDD classification system and is used to standardize comparisons of use of medicines across populations. The DDD may be different for different routes of administration of the same medicine. The DDD is a unit of measurement and does not necessarily reflect the recommended or prescribed daily dose in all settings.

Dosage form: the mean form in which medicine molecules are delivered to their sites of action in the body (e.g. tablet, capsule, elixir, injection or suppository).

First-choice treatment: the initial preferred treatment for any medical condition, recommended on the basis of the available evidence. First-choice treatments for common infections are often Access antibiotics with a positive benefit–risk ratio and low resistance potential, especially in primary care.

Fixed-dose combination: a combination of two or more active pharmaceutical ingredients in a fixed ratio of doses. A commonly used antibiotic available in this form is the combination of amoxicillin with the beta-lactamase inhibitor clavulanic acid. Many fixed-dose combination antibiotics, however, are classified as Not recommended in AWaRe. See also AWaRe.

Global Antimicrobial Resistance and Use Surveillance System (GLASS): a WHO system that promotes and supports a standardized approach to the collection, analysis and sharing of national data on AMR and AMU at global level. GLASS data are updated annually and published on a dashboard.

Medicine-level data on AMU: Data on AMU that provide information on the types and quantities of antimicrobials used by a population over a defined time and collected by routine surveillance. Medicine-level data do not include information on patient or prescriber characteristics, indication or treatment regimen (such as dose, formulation, duration), which differentiates them from clinical data on AMU. Medicine-level data are easier to collect, especially on a large scale.

Metric: Some sources define metrics as raw quantitative measures (e.g. DDDs) and indicators and the values derived from those metrics (e.g. DDDs/1000 inhabitants per day). They are used to assess trends or the appropriateness of AMU. There is, however, no consensus on the distinction between metrics and indicators. In this document, “metrics” refers to all quantitative measures of AMU, whether raw data or derived numbers.

Not classified antibiotic: Antibiotics that have no ATC/DDD and are not (yet) included in the AWaRe classification. In GLASS, they are combined with Not recommended antibiotics into Not classified/not recommended.

One-Health approach: An integrated, unifying approach to a sustainable balance and optimization of the health of people, animals and ecosystems. It recognizes that the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent. The approach mobilizes multiple sectors, disciplines and communities at various levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective requirements for clean water, energy, air and safe and nutritious food, taking action on climate change and contributing to sustainable development.

Primary data source: original data collected directly by a researcher for a specific purpose, such as a survey, interview, observation or experiment. The data are first-hand, current and relevant to the research question. When primary data are not available, secondary data sources may be required. See also secondary data source.

Route of administration: the route by which a medicine is administered into the body. A common distinction is between oral and parenteral (e.g. intramuscular and intravenous) administration.

Second-choice treatment can be used instead of first-choice treatment in case of a contraindication, failure, adverse effect or lack of availability of the first-choice treatment.

Secondary data source: data originally collected by other individuals, organizations or institutions such as governments, researchers, nongovernmental organizations or companies for purposes different from the research in which they are intended to be used. Such sources include reports, academic publications and databases. While they are easier and quicker to access, they may not be fully aligned with the specific research question.

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1 Introduction

Health Workforce in Kisumu Country, Kenya, 2024.

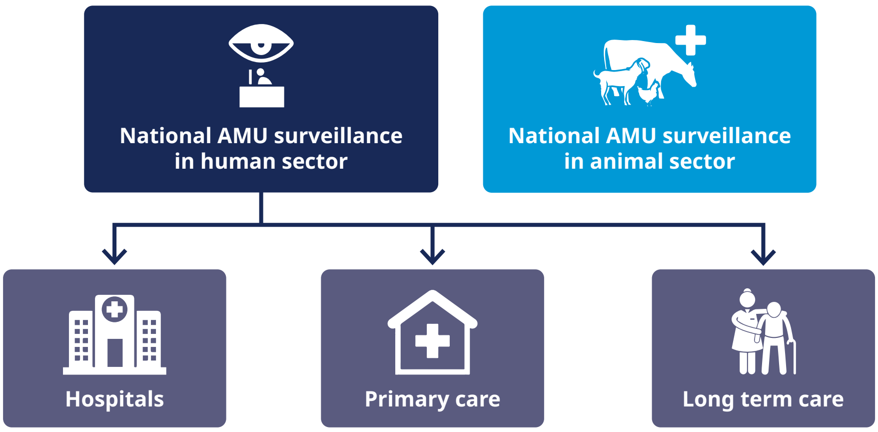
1.1 Monitoring AMU to improve patient care and contain AMR

Inappropriate use of antimicrobials is a primary driver of the emergence and spread of AMR (*1*). In recognition of this fact, the Global Action Plan on AMR endorsed by the World Health Assembly in May 2015, emphasizes the importance of effective action to optimize antimicrobial use (AMU) (*2*). After adoption of the Plan, WHO introduced the AWaRe classification of antibiotics in 2017 as a tool to monitor AMU, define targets and assess the impact of AMS (*3*). Access antibiotics constitute first-choice options for the vast majority of infections encountered in the community and have less impact on AMR than Watch and Reserve antibiotics (*4*). In 2024, during the high-level meeting of the United Nations General Assembly on AMR, global leaders committed themselves to achieving a target of at least 70% of national use of antibiotics in the Access group (*5*).

WHO works with countries to strengthen the evidence base for improving use of antimicrobials through surveillance and research. In this context, WHO launched the Global Antimicrobial Resistance and Use Surveillance System (GLASS) to describe, understand and monitor the global epidemiology of AMR and its main driver, AMU, and to inform strategies for containing AMR (*6*). Despite growing participation in GLASS, many countries still have difficulty in collecting, interpreting and using surveillance data for quality improvement and policy-making.

Surveillance of AMU is a key part of national AMR action plans. The aim is to generate high-quality data to inform and evaluate actions to promote appropriate AMU. AMU surveillance data include medicine-level data (formerly known as antimicrobial consumption – AMC data) that provide estimates of the volume of medicines used and clinical data (formerly known as antimicrobial use – AMU data) to link the information on medicine use to clinical information (e.g. diagnosis, prescriber or ward) (*7*). Medicine-level AMU data can be derived from sources of clinical information. The definition applies to how data are presented (i.e. for medicine-level data, as aggregated, quantitative use of medicines) and not the data source. Medicine-level data can be collected at both national (*8*) and health facility levels (*9*) as defined in WHO GLASS methods. These can be complemented by targeted surveys or audits that provide clinical data (*10*). (Fig. 1).

Fig. 1. Types and structure of AMU surveillance data

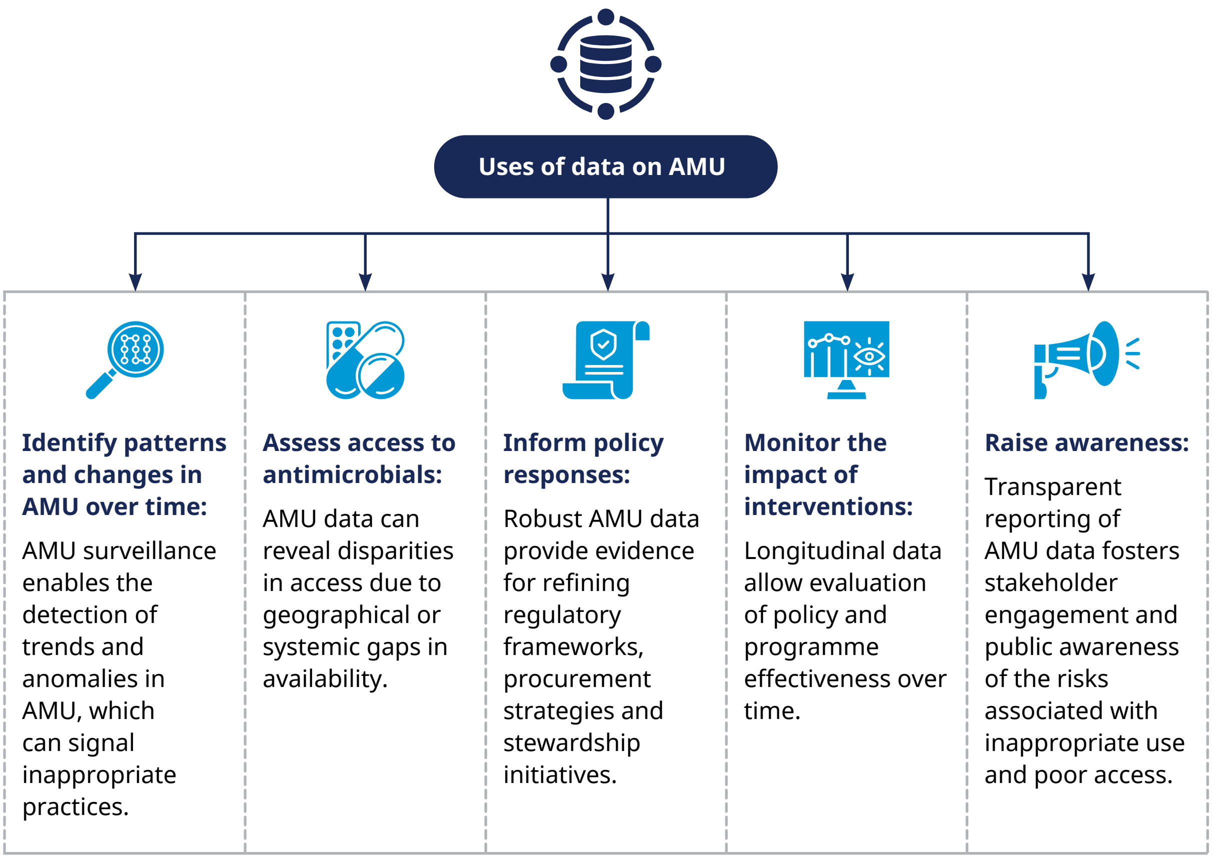


AMU surveillance data are essential for informing policies to promote appropriate, equitable AMU. AMU data can be used to:

- **Identify patterns and changes in AMU over time:** AMU surveillance enables the detection of trends and anomalies in AMU, which can signal inappropriate practices, such as overuse or misuse, prompting targeted investigations and corrective actions. Understanding these dynamics also supports early warning systems for emerging AMR threats and informs the design, implementation and evaluation of national antimicrobial policies, including those outlined in AMR national action plans.

- **Assess access to antimicrobials:** AMU data can reveal disparities in access due to geographical or systemic gaps in availability. This information is critical for ensuring equitable selection and distribution of antimicrobials. It can guide improvements in aspects of the provision of various medicines, such as the supply chain, procurement and financing. It also helps in identifying and addressing barriers to access at points of care, including stock-outs and shortages.
- **Inform policy responses:** Robust AMU data provide evidence for refining regulatory frameworks, procurement strategies and stewardship initiatives. Surveillance supports national medicines policies, including updates to essential medicines lists (EMLs), standard treatment guidelines and prescribing by level of care. It can also inform procurement policies and reimbursement schemes by linking trends in use to policy outcomes, allowing countries to design more effective interventions to promote appropriate use and to reduce the risk of AMR. This allows alignment with international standards and enhances multisectoral coordination.
- **Monitor the impact of interventions:** Longitudinal data allow evaluation of policy and programme effectiveness over time. They can be used in adaptive management, in which strategies can be adapted according to measurable outcomes, ensuring continuous improvement in AMS. It also facilitates benchmarking and cross-country comparisons to identify best practices in stewardship, procurement and regulatory enforcement.
- **Raise awareness:** Transparent reporting of AMU data fosters stakeholder engagement and public awareness of the risks associated with inappropriate use and poor access. It strengthens advocacy, supports behaviour change and reinforces the importance of coordinated action to combat AMR. Surveillance also informs national and local education and training programmes, including awareness campaigns on appropriate AMU. Data-based communication can empower communities and professionals to participate in stewardship.

Fig. 2. Uses of data on AMU



Health Workforce in Kisumu Country, Kenya, 2024.

1.2 Rationale for this guide

The aim of this guide is to ensure effective use of national AMU data by providing information to the target readership (see below) to make the most of the available information. Effective use can enhance evidence-informed decision-making, align national work with global targets and ultimately support containment of AMR through improved use of antimicrobials.

The guide builds on GLASS background documents, including the GLASS method for surveillance of national AMU data (*8*). These resources are the basis for the structure and recommendations presented here, ensuring consistency with established surveillance standards and practices.

1.3 Scope

This document describes the characteristics of data on surveillance of AMU in human health and provides guidance for use of the information to improve AMU. It addresses only medicine-level data on national AMU, although many of its elements are also applicable to analyses at regional, provincial and district levels. Medicine-level data that are sector specific (i.e. primary health care or hospitals) and clinical AMU data will be addressed in future WHO guides. GLASS-AMU surveillance covers several types of antimicrobials (e.g. antibiotics, antifungals and antivirals), and many of the principles outlined here apply to all antimicrobials. The focus of this document, however, is on antibiotics.

To improve readability, this guide refers to AMU without the qualifier "medicine-level" and without specific reference to antibiotics.

1.4 Target readership and structure

Target readership

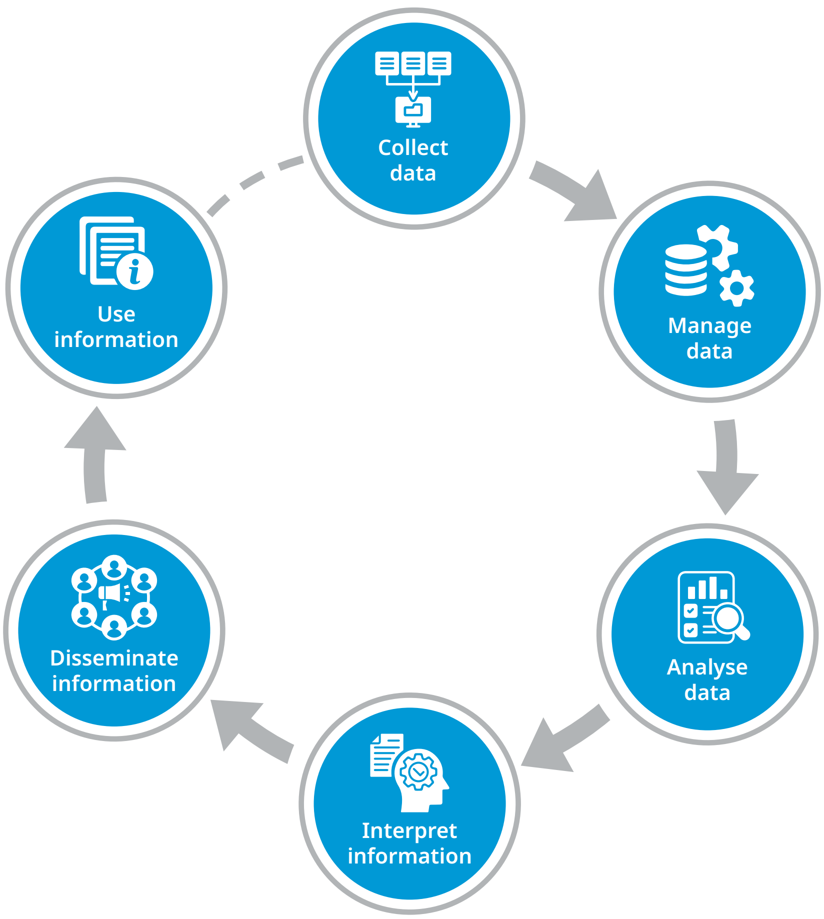
This document is designed for public health professionals and health authorities responsible for monitoring and improving the use of antimicrobials, in addition to pharmacists, doctors and other clinical staff who implement AMS policies and programmes. It may also benefit professionals in sectors other than human health who address AMU and AMR in an integrated surveillance network within a One Health approach.

Data collectors and analysts may also benefit from this guide, as they should understand the purpose, the data requirements and limitations to effectively communicating accurate, relevant information to policy-makers and health practitioners. Clear definition of data requirements and minimization of biases and errors are crucial for reliable interpretation and for planning interventions.

Structure

Surveillance consists of systematic (1) collection, (2) management and (3) analysis of data, which is transformed into information that can be (4) interpreted, (5) disseminated and (6) used to inform and improve AMU (Fig. 3). The sections of this document are organized accordingly.

Fig. 3. Surveillance: from data to action



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2 Collecting data

Medicines on a pharmacy shelf, Kyrgyzstan, 2008.

2.1 Planning data collection

Before initiating data collection for surveillance of AMU, careful planning is important to ensure that the data collected are relevant, reliable and actionable. Effective planning helps to define the objectives, identify appropriate data sources and anticipate challenges such as in data quality and stakeholder coordination. It also ensures alignment with broader health priorities (e.g. national health strategies, AMR action plans, universal health coverage, medicines policies) so that the resulting information can inform decisions. Engagement of health workers, policy-makers and authorities in planning is essential to promote appropriate uptake and use of the findings of surveillance to improve AMU practices. Moreover, establishment of clear governance is critical to ensure sustainable surveillance systems, with effective coordination and defined roles for components and stakeholders.

Box 1 outlines key considerations to guide planning.

Box 1. Key questions to consider in planning AMU surveillance

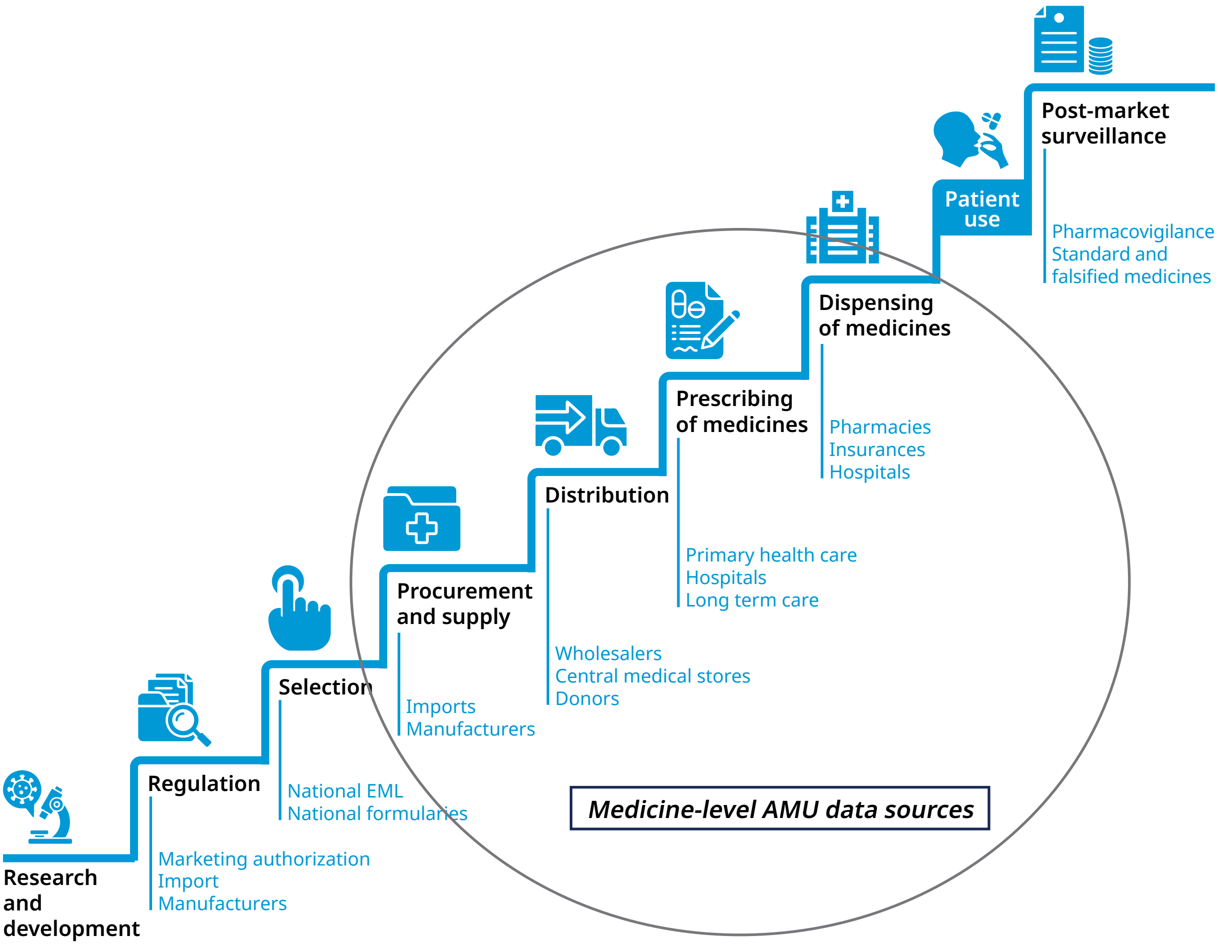
- What problem is to be addressed?
- What data are required to provide actionable information?
- What data sources could be used for AMU surveillance? What complementary data sources could enhance decision-making?
- What are the common limitations of data quality, including coverage and bias, and how can they be mitigated?
- How is the quality of AMU surveillance data assessed in terms of data validation, internal consistency and representativeness?
- Who will be involved in data generation, collation, analysis and reporting?
- Which indicators and targets should be used?
- Who are the target users of the data analysed?
- How are the data presented and disseminated to target users?

2.2 Data availability

National AMU data describe the quantity and types of antimicrobials used at national level. Data collection often relies on secondary data sources, such as medicines-based or aggregated patient datasets maintained for various administrative purposes. Data from these sources may be collected routinely, are readily available and have extensive coverage, making them suitable for comprehensive national surveillance (*8*).

Fig. 4 illustrates the data sources as different points in a medicine's life cycle at which national data can be collected, from records of procurement, supply and distribution, to prescribing and dispensing.

Fig. 4. Sources of AMU surveillance data in the medicines lifecycle

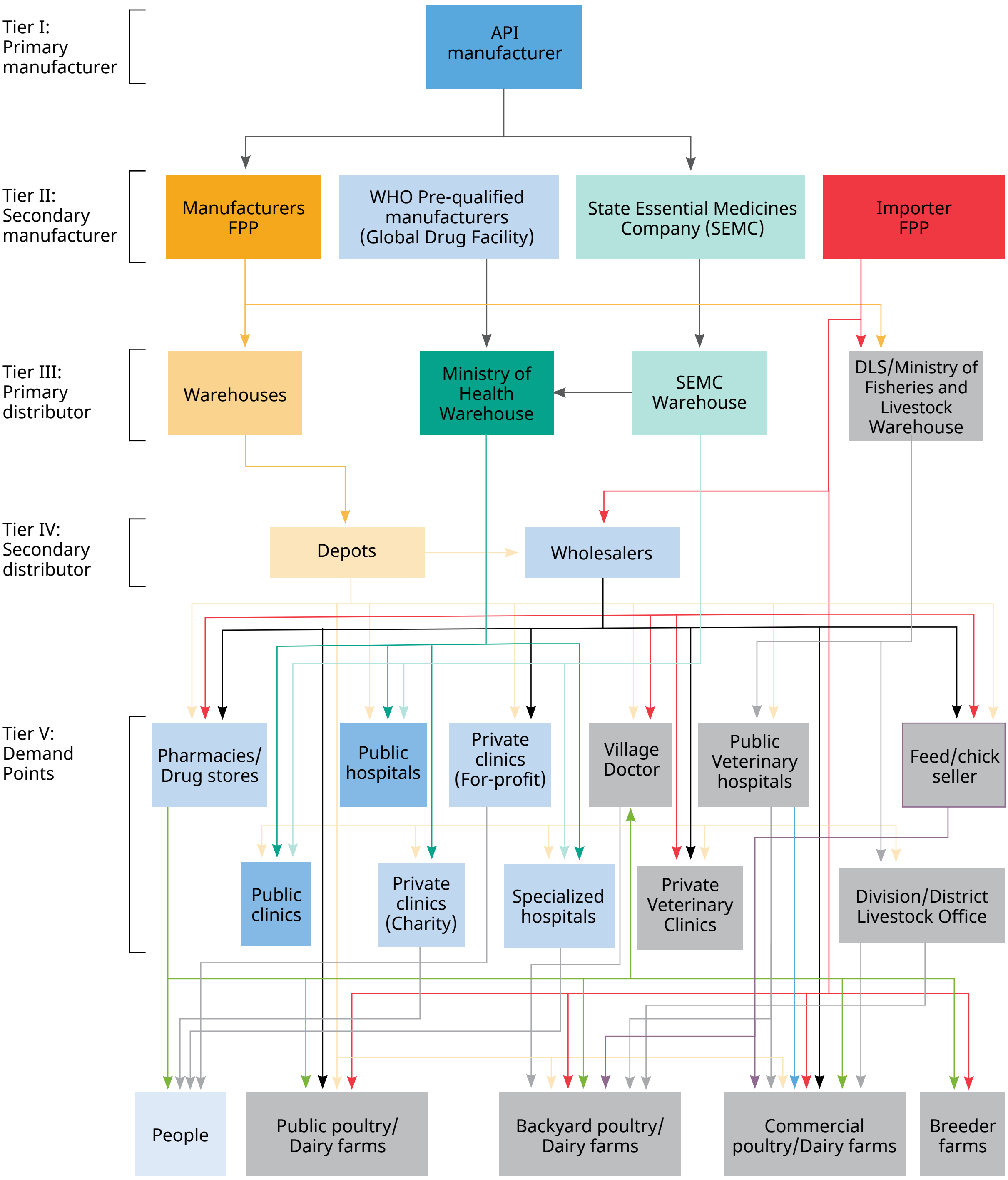


AMU data from these sources may have inherent limitations, as they were not originally collected and recorded with surveillance as their primary purpose. The data may not be standardized (without coding according to international classifications such as the Anatomical Therapeutic Chemical/Defined Daily Dose i.e., ATC/DDD system) (11, 12) and may lack essential elements such as pharmaceutical form or route of administration. The completeness and representativeness of data differ, which affects whether data accurately reflect actual use by people. Such data may not be readily accessible in electronic format but are in paper-based record-keeping systems. Other challenges include the cost of obtaining records, reluctance of data owners to share data and confidentiality concerns or legal obstacles (8).

This document provides a flexible, generic framework of data sources and the main data elements to assist countries in mapping their data providers. The purpose of the adaptable structure provided in this document is to help countries to identify and organize their data sources according to their context, local medicine supply chains, health system structures and stakeholders.

Fig 5 is a schematic overview of the supply chain of antimicrobials in hypothetical country A. The scheme highlights points at which national data on AMU can be collected, depending on data availability and surveillance goals. It highlights the many possible data sources and the relations among the many players involved, from procurement to patient. Medicines supply, health services and patient access to care and antimicrobials are intricate systems characterized by dynamic interactions, nonlinearity and the interdependence of stakeholders.

Fig 5. Circulation of (antimicrobial) medicines in hypothetical country A



Schematic of the network structure of the antimicrobial supply chain for human and animal sectors in country A illustrating the flow of product

Abbreviations: API - Active Pharmaceutical Ingredient; DLS - Department of Livestock Services; EDC - Essential Drug Company Limited; FPP - Finished Pharmaceutical Product; SEMC - State Essential Medicines Company

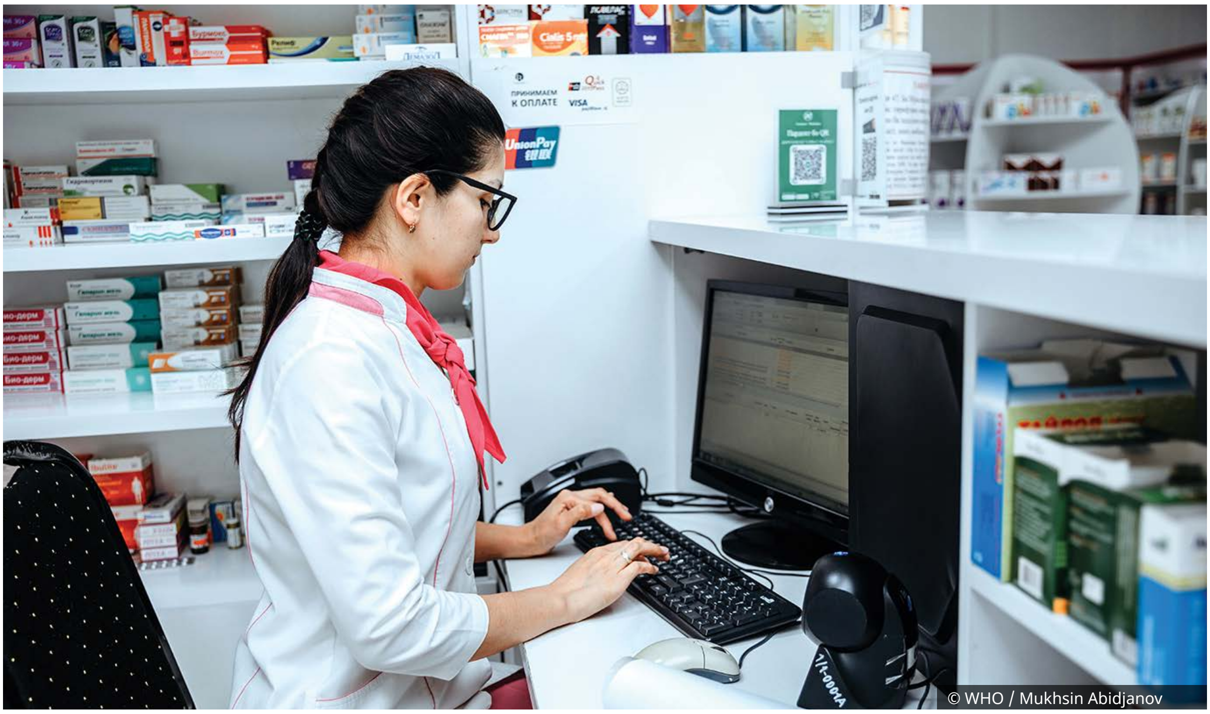
2.3 Characteristics of national data sources

National data on AMU can be sourced from records related to procurement and supply, sales, distribution, prescribing, dispensing or reimbursement collected by various stakeholders. The WHO GLASS methodology (*8*) provides an overview of the strengths and limitations of each data source (Fig. 6). Countries should map the specific characteristics of their supply chain and identify relevant, readily available data sources on national AMU. Some tradeoffs between data availability and quality are described in section 4.1 on data quality.

Understanding of the strengths and limitations of various types of data facilitates interpretation of national AMU data. For example, data collected from sources closer to the patient and actual use, such as dispensing, prescribing or reimbursement records, provide the most precise information, including data disaggregated by health-care level (community vs hospital), sector (private vs public), subnational administrative area (e.g. region, district) and sometimes patient demographics. These sources are often more sophisticated, resource-intensive and less attainable in the short term in many settings.

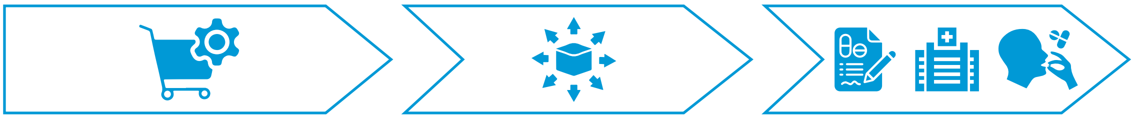
Obtaining complete data on dispensing or prescribing can be challenging, particularly in low- and middle-income countries if there is limited use of electronic databases. Depending on the health-care system and legal and regulatory requirements, data on reimbursement may be available only for a subpopulation (e.g. the population with access to insurance coverage) or to a subset of antimicrobials covered by the insurance system, limiting its comprehensiveness at national level.

"Procurement data" in this document refers to either records of imports or of local manufacturing intended for domestic use. While the combination of data on imports and local manufacturing cover the national population, it may include antimicrobials that are ultimately not used for patients (e.g. because they are never dispensed or are stockpiled for future use) or are used in the veterinary sector, which can be misleading. Additionally, under- or no reporting of donations of medicine by countries, nongovernmental organizations and pharmaceutical companies can affect the completeness and accuracy of the data. Although such data are a good starting point for resource-limited surveillance systems, they also provide robust national data coverage for most countries. GLASS recommends distribution-level data (e.g. orders by pharmacies, clinics or hospitals) for moderately mature systems to ensure data of acceptable precision, disaggregation and national coverage.



Pharmacy in Dushanbe, Tajikistan, 2022.

Fig. 6. Characteristics of sources of national medicine-level data



	Procurement and supply data	Distribution data	Prescribing, dispensing, reimbursement data
Type and source of data	• Type: Quantities of antimicrobials imported and manufactured locally (in doses, units, packages) • Source: Regulatory administrative records of imported and locally manufactured medicines from all public and private entities	• Type: Quantities of antimicrobials distributed to hospital and community pharmacies by distributors[a] and wholesalers[b] • Source: Administrative records collected from distributors, wholesalers, central medical stores, donations, disease programmes and nongovernmental organizations	• Type: Quantities of antimicrobials prescribed, dispensed or administered to patients • Sources: Prescribing records, pharmacy sales records, insurance claims
Advantages	• Often provide the most complete national data • Help to understand the market, availability, cost and affordability	• Good proxy for actual use of antimicrobials • Often provide complete national data • Disaggregation is possible by health-care sector and level, subnational area and season	• Best proxy for actual AMU • Disaggregation of data by health-care sector, level, subnational area and season possible • Some demographic data and patient-specific data might be available.
Disadvantages	• Reflect quantities of antimicrobials procured or manufactured locally, which is an imperfect measure of AMU by patients (see below) and therefore the least accurate proxy of AMU • Does not account for stockpiling or wastage of antimicrobials • May result in temporal differences between import and manufacturing cycles and annual surveillance data collection cycles (e.g. antimicrobials imported in one calendar year may be used only in a later calendar year) • Re-export of medicines may distort actual quantities used domestically. • Stratification by health-care level, subnational area or season usually not possible. • Legal reporting protocols need to be established by the national regulatory authority for medicines	• Time-consuming data collection, particularly when there are numerous wholesalers and distributors • Risk of less completeness, representativeness and coverage if data from some wholesalers or distributors are missing • Legal reporting protocols need to be established by the national regulatory authority for medicines	• Compilation of data from many health facilities and pharmacies requires advanced, costly tools and may therefore reduce representativeness because of incomplete coverage • Health insurance schemes may cover a limited, selected proportion of the population (e.g. government employees), which may reduce the representativeness of reimbursement data. • Legal reporting protocols to be established by the national regulatory authority for medicines • Antimicrobials dispensed without a prescription are not captured.
Use cases	Good starting point for national medicine-level surveillance when there are limited capacity and resources for collecting good-quality, comprehensive data from sources closer to actual use.	Suitable when there are few wholesalers and distributors or as an improvement over procurement or supply data. Lack of mapping of donations and vertical programmes can result in incomplete or skewed estimates of antimicrobial availability and use.	Relevant in countries that have electronic medicine record or dispensing systems integrated or collated for all health sectors and care levels.

[a] Distributors purchase medicines from manufacturers.
[b] Wholesalers purchase medicines from distributors.

Primary Health Care (PHC) setting, Georgia, 2024.

When several data sources are used in AMU surveillance, such as procurement, distribution records and facility-level data, there is a risk of double counting, which can lead to inflated estimates of AMU. To ensure data accuracy, it is essential to identify and remove duplication from all sources. This requires careful mapping of data flows, clear definitions of what each dataset represents and coordination among reporting systems. Data reconciliation and cross-referencing of records can help to distinguish between medicines that were procured, distributed and actually used by patients, thereby improving the reliability of surveillance.

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3 Managing data

National Paediatric Hospital, Cambodia, 2015.

A basic step in establishing or strengthening AMU surveillance is systematic mapping of all available sources of AMU data along the supply chain. Mapping clarifies the data landscape and identifies overlaps and the scope and limitations of each dataset, thereby ensuring more coordinated, comprehensive surveillance. Once data sources are mapped, compilation of national AMU data requires careful attention to several technical aspects, including data quality and coverage, data format, classification system, interoperability, data cleaning and protection.

Two important aspects to be considered in the management of AMU data are, first, an information technology (IT) solution for managing (collecting, analysing and reporting) the large volume of AMU data that ensure consolidation, interoperability, data security, compliance with legal requirements and can be used for AMS. Secondly, legal agreements with the data providers must be in place, which clearly outline how the data can be used and shared with the public.

3.1 IT solutions

As described above, AMU data can be collected from many sources, including procurement systems, health facilities and regulatory agencies, each of which has a distinct data format and level of granularity. (See section 2.3 for further details.) To guarantee consistency and usability, wherever possible, common data elements should be collected and consolidated in a central database of product- and substance-level information. Interoperability, which is the seamless exchange, interpretation and use of data from systems or databases, is essential. The central database should also include relevant classification systems, such as the ATC/DDD system (*11*), the WHO AWaRe classification (*4*) and relevant national systems (e.g. the national EML, the national list of reimbursed medicines, national pricing databases) to facilitate meaningful analysis. Countries are encouraged to adopt or develop analytical tools for processing and visualization. The IT solutions of countries that participate in global surveillance systems such as WHO GLASS should be capable of exporting data in the formats required by those global systems. While tools to facilitate creation of the required formats may be provided by the global systems (For example, WHO GLASS-AMU surveillance provides a Microsoft Excel® template to facilitate collation of national data in the required format.), long-term sustainability requires that countries generate the standardized, required outputs by themselves (*8*) to ensure seamless integration and alignment among systems to facilitate global data-sharing.

Importantly, all systems must ensure data privacy and security, including protection of personal and confidential information as well as commercially sensitive data, such as medicine sales figures. IT systems for managing AMU data should be designed with such constraints in mind and have safeguards to prevent unauthorized access and ensure data security and compliance with relevant national and international data protection regulations.

3.2 Legal requirements

Legal agreements must be established with data providers to access their data for the purpose of AMU surveillance. Such agreements can be in the form of either a law mandating all data providers to share their data in the frame of national AMU surveillance or a legal contract between the authority in charge of AMU surveillance and individual data providers. It is important to keep in mind that such legal agreements with data providers may limit how certain data, such as product-level details, can be shared or disclosed, particularly to the public. In a worst-case scenario, it might not be possible to use product-level data for legal reasons; the alternative might be to use more aggregated data, such as substance-level data, to monitor AMU.

© WHO / Jerome Flayosc

4 Analysing data

Telemedicine in Kazakhstan: smart health services delivery, 2019.

Section 4.1 addresses the basic concepts of data quality. Readers familiar with this topic can go to Section 4.2.

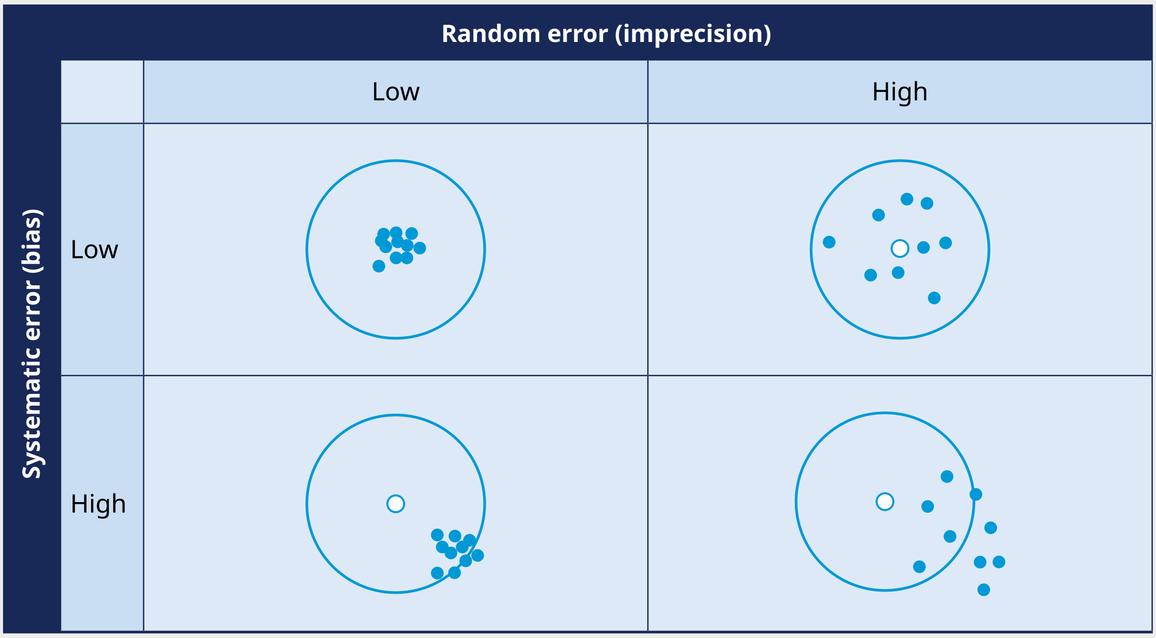
4.1 Assessing data quality

A well-functioning surveillance system accurately and consistently captures the total volume of AMU in the target population, location and selected period. The stability of structure and organization over time enables tracking of trends and monitoring changes in AMU. National AMU surveillance systems based on internationally recognized standards such as the ATC/DDD system, common metrics and standardized data collection methods also ensure that data are comparable among countries and over time.

In practice, most surveillance data are subject to limitations (Fig. 7), including:

- biases, which are systematic errors that consistently skew estimates in one direction, and
- random errors, which reduce the precision of the estimates.

Fig. 7. Bias and random errors



Data quality can be assessed by comparing estimates from different sources or with data from previous years. Studies in which consistent methods are used over time can be considered benchmarks for identifying discrepancies and for highlighting areas that require further investigation. Unexpected findings (e.g. very high or low use of certain antimicrobials or classes as compared with previous years or other countries; sudden unexplained differences in use or use pattern; large differences within or among countries) or outliers may signal underlying issues of data quality and should be examined. Benchmarking studies can reveal unexpected patterns that may indicate issues with data quality (Box 2).

Box 2. Example of identification of issues in the quality of AMU data

Country	Anomaly detected	Possible explanation[a]
A	300% increase in fluoroquinolone use over that in previous years	Data entry or coding error In some situations, the increase may be real, e.g. in the context of a disease outbreak, a change in treatment guidelines or shortage of first-choice antibiotics. Before attributing the increase to any such event, errors in data entry or coding must be excluded.
B	Zero macrolide use reported; no previous data available	Incomplete data submission Macrolides such as the Watch antibiotics azithromycin and clarithromycin are among the most widely available and commonly used (and overused) antibiotics globally. No country in the 2022 GLASS-AMU surveillance report had zero use of macrolides. Zero use of this class is therefore not plausible and probably represents incomplete data submission.
C	Sudden increase in cefapirin use (J01DB08) with an equal decrease in cefazolin use (J01DB04) as compared with previous years	Coding problem (J01DB08 instead of J01DB04) In some situations, the increase may be real, due, e.g. to a change in treatment guidelines or in the national EML or to a shortage of first-choice antibiotics. Before attributing the change to any such event, errors in data entry or coding must be excluded.
D	Overall national AMU is five times higher than the global average.	Data entry or coding error, double counting While there is wide variation in AMU among countries, extreme outliers in both directions indicate issues with data quality. Extremely low use of antibiotics may suggest incomplete data.

[a] This list is not exhaustive.

[b] Always check for data errors first; if none are found, consider other possible explanations such as outbreaks, change in treatment guidelines or stock shortages.

National AMU surveillance often relies on full population (census-type) data from one or more sources, which are often systems originally designed for other purposes. The quality of these data depends heavily on how the surveillance system is structured, including the choice of data sources, the type of AMU data collected (see section 2.3) and the broader context of the country's pharmaceutical system. Additional limitations may arise if data collection, preparation or use of standardized classifications are not conducted rigorously or without proper quality assurance.

National AMU data are typically high-level data and may have some inherent quality limitations. National data experts such as epidemiologists, pharmacists and data analysts who understand the context and characteristics of the data, both before and during analysis, can support selection of appropriate analytical methods (e.g. descriptive statistics, stratification by sector, benchmarking), the choice of relevant metrics and development of clear disclaimers acknowledging the limitations of the data, to accompany dissemination of results.

Some countries use market research data purchased from private companies. These data are typically estimates from samples, extrapolated to represent national use. In such cases, the data provider should supply detailed information on the method and characteristics of the data, including any weighting estimates used. Often, such data are not provided.

Regardless of the data source, this guide highlights five key dimensions of data quality that national experts should consider during analysis and reporting:

- completeness – ensuring that all relevant data are captured;
- representativeness – ensuring that the data reflect the target population or system;
- precision – evaluating the level of detail and accuracy of the data;
- internal quality – checking the consistency, validity and reliability in the dataset; and
- internal comparability – determining whether the data can be compared across periods, regions or systems in the country (*13*)

4.1.1 Completeness

Data completeness, also known as "external data completeness", refers to the extent to which the data capture the total volume of AMU during a defined period (e.g. one calendar year), The aim is to determine real use by patients, as this is likely to have the largest impact on AMR. In reality, it is impossible to estimate real use, because, for example, patients may not complete their treatment or the dispensed antibiotics may contain more doses than prescribed (*13*).

In analysing and interpreting data, the following questions should be considered.

- Does the dataset represent the total volume of AMU during the defined period, geographical area and population?
- If not, what proportion of the total volume is estimated to be missing or unaccounted for?
- Is it appropriate to extrapolate the data to estimate use by the entire population? In other words, are the data for the subset representative of the entire population (e.g. with regard to demographic and socioeconomic characteristics)?

Ideally, national AMU surveillance data capture the full volume of AMU. In practice, however, data coverage is often suboptimal and depends on the type and source of data. Common examples of data incompleteness are outlined in Box 3.

Incomplete coverage results in underestimation of the actual volume of AMU. Moreover, if certain antimicrobial groups, health-care sectors or population segments are underrepresented or excluded, the observed patterns of use may be distorted (see also section 4.1.2 on data representativeness). Attempts should be made to identify missing data and to assess how their absence affects both the estimated volume and the observed usage patterns or how their absence might be overcome (e.g. supplemented by another source, such as a representative survey).

Box 3. Reasons for missing data according to data type

Procurement data: may exclude locally manufactured or directly imported antibiotics if these are not systematically recorded. Donations may follow a different distribution channel and therefore be missed.

Distribution and wholesale data: In countries with complex supply systems, with the involvement of many wholesalers, sub-distributors and supply chain actors, data may be available from only a limited number of sources (e.g. central medical stores, major wholesalers), especially if there is no regulation mandating comprehensive reporting. Certain specialized hospital units (e.g. oncology wards, intensive care units) may operate under distinct purchasing and distribution systems.

Dispensing data: Coverage may be limited if only a small subset of pharmacies[a] or dispensing facilities report data.

Reimbursement data: Completeness depends on the scope of the insurance scheme, including which antimicrobials and population groups are covered.

Market research data: are typically based on sampled data, which are extrapolated to national level, assuming that the sample is representative, which may not always be true. The methods used to extrapolate data are not always publicly available.

Informal markets data: Data on AMU in informal markets, such as food markets at which antibiotics are sold in single units, are often anecdotal or based on small studies and are difficult to quantify at national level. Despite these limitations, such use is real and should be monitored and addressed nationally.

[a] Complex pharmaceutical systems, such as large pharmacy chains, supermarket drugstore sections and mixed public–private pharmacies, may be difficult to map accurately.

4.1.2 Representativeness

Representativeness refers to the extent to which surveillance data accurately reflect the occurrence of the event under surveillance in an entire population (*13*) In the context of national monitoring of AMU, surveillance systems should provide estimates that represent all antimicrobials used in the country at all levels and sectors of the health system.

Data representativeness is linked to data coverage. Representativeness is more likely to be high when coverage is high. Therefore, when coverage is lower, representativeness may be compromised, depending on the data sources used and the volume and nature of the missing data.

Before analysing, interpreting or reporting AMU data, the scope and limitations of the data should be assessed critically. Key questions that could be asked include the following.

- Are any sectors or levels of care or geographical regions systematically excluded or inadequately represented? For example, if the data come primarily from large or university hospitals with greater surveillance capacity, they may not accurately represent the broader hospital and national landscape. Additionally, private pharmacies are often excluded from surveillance, limiting representation of the primary care sector.
- Are specific antibiotic substances consistently missing from the dataset? This may reflect coding or data entry errors or may be linked to exclusion of the settings in which these antibiotics are primarily used. For example, certain Reserve antibiotics may be available in the private sector and not in the public sector.
- What is the likely impact of these gaps on national estimates?

Lack of representativeness can lead to biased estimates of AMU – either over- or underestimates of the use of certain substances. The impact of such gaps on overall use depends on the market share of the excluded data and the broader characteristics of the national pharmaceutical landscape.

Table 1 provides examples of issues of representativeness and their potential effects on estimates. Regardless of the source or scope of the data, acknowledgement of such limitations and analysis of their potential implications will allow interpretation of the results in the light of the limitations.

Table 1. Issues of representativeness that may arise in AMU surveillance

Type of representativeness	Issue	Consequences
Health care sector	Overrepresentation of the public sector	Estimates may favour government-procured antibiotics, mainly those on the national EML, potentially over-representing Access antibiotics.
	Overrepresentation of the private sector	Estimates may overstate non-essential Watch antibiotic use, as private sector practices, driven by financial incentives and limited regulation, inappropriately favour broader-spectrum or newer antibiotics.
	Exclusion of over-the counter (OTC) sales and informal markets	Systematic underreporting of actual use levels. Exclusion of OTC antibiotics may skew AMU data towards guideline-recommended antibiotics.
Health-care level	Overrepresentation of community level	Community-level AMU, which often corresponds to > 90% of total, may under-represent parenteral and Reserve antibiotics, which are more commonly used in hospitals.
	Overrepresentation of hospital care	As hospitals account for about 10% of national AMU, data from their records are insufficient for tracking national trends. Hospital data may over-represent use of parenteral, broad-spectrum Watch and Reserve antibiotics, because more severe infections are treated in hospitals, and there is a higher prevalence of AMR.
Antimicrobial substance	Exclusion of programmes	Exclusion of disease-specific programmes (e.g. for HIV, tuberculosis, malaria) may result in lack of data on AMU, especially in countries where such programmes serve large populations. For example, HIV programmes often provide antibiotics to treat a wide range of sexually transmitted infections and opportunistic bacterial infections, which may not be captured by general AMU surveillance systems.
	Exclusion of reserve antibiotics	Reserve antibiotics may be procured by special import mechanisms, emergency use authorization, named-patient imports or from international donors or special access schemes. If they are not tracked, their use may be overlooked entirely.

The Renewed Partnership to Strengthen Pharmaceutical Systems, Ethiopia, 2016.

4.1.3 Precision

Precision refers to the extent to which surveillance data accurately reflect the actual situation during a defined period and in a defined geographical area and population. In the context of national medicine-level AMU data, precision is closely linked to completeness, the extent to which the data capture the full volume of AMU during the specified time and throughout the national territory or within specific regions, sectors or levels of care. Precision reflects the comprehensiveness and accuracy of data within the defined scope (13).

The following questions should be considered:

- Does the total annual dataset reflect the actual volume of AMU in the country or in a specific subnational area during the reporting period?
- Do stratified estimates accurately represent use within the specific level or sector of care during the same period?

Data precision is closely linked to the type and specificity of the surveillance data collected and to the structure of the pharmaceutical distribution system. Box 4 provides an overview of how different types or levels of data may offer varying degrees of precision, while Box 5 presents examples of poor precision in estimates stratified by level of care.

Precision may also be compromised in contexts in which informal channels of distribution play an important role. For example, antimicrobials may be re-exported informally from one country to another or enter a country through porous borders and therefore not be recorded. Additionally, in some countries, antimicrobials registered for human use may be diverted for veterinary use or vice versa. These practices are often difficult to quantify, as they are typically unregulated or illegal. Reliable information on such issues usually requires targeted surveys or investigations by regulatory authorities.

Box 4. Influence of data type on precision

Procurement data: Such data typically reflect importation or local manufacturing cycles rather than real-time use by people. Thus, they may provide less precise estimates of actual use. Consideration of whether antimicrobials are re-exported, at least through formal channels, will avoid overestimation.

Distribution and wholesale data: Such data can provide a closer approximation of national use but may still be influenced by stockpiling practices or redistribution between regions or facilities, which can affect temporal and geographical precision.

Dispensing or reimbursement data: Such data generally offer the most accurate reflection of actual use by people in a given year and country, as they are directly linked to use by patients and actual dispensing events.

Box 5. Challenges to precision of stratified estimates

Use patterns and stewardship policies often differ importantly by community and hospital sector. Disaggregation is therefore recommended, in view of the different types of antibiotics used in each setting.

Differences in health-care systems can, however, affect the precision of stratified estimates.

- In some high-income countries, hospital data may also include information on AMU in long-term care facilities, such as nursing homes, potentially broadening the scope of what is classified as hospital use.
- In some low-income countries, antibiotics used for inpatients may be purchased from community pharmacies located near hospitals. This can blur the distinction between community and hospital use.

Such contextual differences should be considered during analysis and interpretation, as they can significantly influence the accuracy of stratified estimates by level of care.

4.1.4 Internal quality

Internal data quality consists of the completeness, accuracy, consistency and reliability of the values recorded in a dataset. It addresses the question: Are the data internally consistent and free from obvious errors?

Missing values, duplicate entries or incorrect information can be introduced at any stage of data collection (*13*) Strategies to ensure high internal quality include:

- defining variables (i.e. active ingredient, pharmaceutical form, strength and quantity used as minimum data elements) and establishing standardized data collection and validation procedures;
- maintaining an electronic registry of antimicrobial products, with unique product identifiers; and
- automating systems for data entry, extraction, transmission, validation, analysis and reporting.

For example, large year-to-year variations in overall AMU or specific classes or significant discrepancies from the results for similar countries, such as an unusually low total use or a disproportionately high use of parenteral formulations, should be investigated (see above). Such anomalies may indicate underlying issues with data quality, especially if there are no known differences in the representativeness of data.

ATC codes and DDD values are dynamic and are regularly updated with evolving clinical evidence. Therefore, analysis of all data with the latest version of the ATC/DDD index will maintain consistency and comparability over time.

4.1.5 Internal comparability

Internal comparability refers to the consistency of surveillance data among periods, levels of care and sectors in a country at national or subnational level. Internal consistency is essential for identifying trends in AMU and for interpreting changes accurately and meaningfully (*13*).

A key question to be considered is whether data be compared reliably by year, region, level and sector in the country.

Any changes in data sources, methods, geographical coverage or the levels and sectors of care included may affect comparability and should be assessed. Examples of such changes are:

- extending surveillance to include private sector data or additional levels of care; and
- changing from one data source to another, such as from import or manufacturing records to reimbursement data.

Documentation and communication of such changes when reporting results will ensure that data users understand the potential limitations and do not misinterpret differences that may stem from methodological differences rather than actual changes in AMU.

4.2 Defining metrics

4.2.1 Data elements

Assessment of AMU involves relating the quantities of used active ingredients to the corresponding population sizes and time frames, as the absolute quantity of AMU depends on those factors. Such standardization allows comparisons of different settings and over time without interference from commercial or manufacturing changes in presentation, format or composition. AMU is calculated as the ratio of the quantity of antibiotics used to the population and time. The result is also known as the density of AMU (*14*).

$$\text{Antimicrobial use rate} = \frac{\text{Quantity of antimicrobials used}}{\text{Population x time}}$$

The data elements, i.e. numerator and denominator, for calculating the density of AMU are presented in Table 2.

Table 2. Data elements for calculating the density of AMU

Component	Definition	GLASS recommendations for national AMU surveillance
Numerator: Quantity of antimicrobials used	Total amount of antimicrobials used (May refer to all antimicrobials, specific groups of antimicrobials or individual antimicrobials and be measured in different units, such as DDD)	Total quantity of systemic antimicrobials in DDD used at national level in 1 year Total quantity of fluoroquinolones in DDD used at national level in 1 year. Total quantity of colistin in DDD used at national level in 1 year.
Denominator: Population	Total number of people covered by surveillance at national or subnational level	Total national population
Denominator: Time	Duration over which the AMU is measured	Per calendar year

In terms of antimicrobials covered by national surveillance, countries participating in GLASS-AMU surveillance are asked to report all mandatory antimicrobials available on their market, specifically, antibacterials for systemic use (ATC codes: J01, P01AB, A07AA). Countries may optionally report on antifungals (J02, D01B, A07AA), antivirals (J05), tuberculosis medicines (J04A) and antimalarials (P01B) (*8*).

The population denominator used for calculating AMU indicators must be defined. This includes consideration of whether certain subpopulations, such as individuals living in specific geographical areas, refugees or those not covered by national insurance schemes, are included in population estimates. When surveillance data do not cover the entire population, countries are encouraged to use the best available estimates of the population actually covered.

The periods used may be shorter than 1 year (e.g. 1 or 3 months), which may be useful for evaluating seasonal patterns.

National data can be presented as aggregated data, ideally also disaggregated by health-care level (primary care and hospital) and health-care sector (public and private) (*14*).

Contextual information should be described when reporting the results of national surveillance. It usually includes:

- type and sources of data (see Fig. 6);
- health-care levels and sectors covered;
- antimicrobial agents (e.g. confirmation of mandatory and optional antimicrobials);
- groups of patients or facility types excluded, if relevant;
- factors that may affect AMU:
  - shortages (e.g. of antibiotics);
  - epidemic events (e.g. the coronavirus disease 2019 [COVID-19] pandemic, cholera outbreaks);
  - changes in medicine regulations and policies (e.g. banning of non-recommended fixed-dose combinations, availability of new or updated national treatment guidelines);
  - published alerts about the quality of a specific antimicrobial resulting in a shift to use of alternative substances in the same therapeutic group; and
- the method used to classify substances and estimate quantities of use (e.g. ATC/DDD system and versions).

4.2.2 Data metrics

Reporting of AMU per population and time requires specific metrics for both the numerator and the denominator (*8*).

Numerator metrics are used to quantify the volume of AMU, typically expressed in doses, units or grams. The preferred metric for national surveillance is the DDD. For standardization, WHO GLASS uses DDD to quantify AMU and the ATC classification to codify medicines. The ATC/DDD system was established in the 1970s for classifying medicines for administrative and drug use. The WHO Collaborating Centre for Drug Statistics Methodology has been maintaining it since 1982.

The DDD is defined as the average maintenance dose per day of a drug used for its main indication in adults (*11*). The advantage of the DDD is that it is a standardized unit of measurement. Unlike price, currency, strength or package size, which may vary among data sources and settings, the standardized measure enables assessment of trends and comparisons of medicines, populations and countries, regardless of differences in package size, strength or price.

The main disadvantage of the DDD for AMU is that it is designed for research on drug use and is thus based on the assumed average daily dose of a drug for treating infections of moderate severity in a 70-kg adult. Therefore, the DDD does not necessarily represent the most common doses of a specific AMU in all settings or in all populations. For example, hospitals often use higher doses of certain antimicrobials according to the severity of infections. One such case is flucloxacillin, for which the DDD for parenteral use is 2 g, although, in actual clinical practice, daily doses of 8–12 g are used frequently. Additionally, use of DDDs can result in underestimates of the doses of antimicrobials for children. As children often require lower dosages because of their smaller body size and different pharmacokinetics, use of DDDs can lead to underestimation of AMU in paediatric populations by introducing systematic bias. Additionally, children often require weight-based dosing, so that there is no single "standard dose" for children (in contrast to adults). The DDD method nevertheless remains the most reliable proxy for assessing AMU, especially in comparisons of settings, when no real-world, complete data from electronic medical records are available.

Other metrics might have to be used be to capture all aspects of AMU comprehensively. See Table 3 for examples. In different sectors (e.g. human, animal, agriculture, environment), the common metric for comparing AMU is the mass of antibiotics; however, this metric is influenced by the strength of medicines, and higher-dose antimicrobials are overrepresented.

Table 3. Common numerator metrics for AMU

Metric	Description	Advantages	Disadvantages
Number of DDD	Assumed average maintenance dose per day of an antimicrobial used for its main indication in adults	Standardized and internationally comparable; useful for trend analysis and benchmarking	May not reflect actual prescribed or used doses; less precise in settings with a high proportion of paediatric patients
Number of packages, tablets, or other formulation items	May complement DDD metrics for measuring specific aspects of procurement not well captured by DDD	Relatively simple to collect from procurement data; useful for logistics and supply chain monitoring	No dose standardization; not suitable for comparing settings or substances
Mass expressed in kg or tonne	Common metric for mass, enabling measurement and comparison of medicine-level use in the human, animal and agricultural sectors	Useful for One Health comparisons; easy to aggregate among sectors	Does not account for potency or dosage; not suitable for clinical use analysis

Metric	Description	Advantages	Disadvantages
Number of recommended daily doses	Average daily dose recommended in local or national guidelines or by experts	Reflects local prescribing practices; useful for internal comparisons (e.g. hospital vs primary care).	Not standardized among countries; limited comparability of settings

The common denominator metrics for national AMU are shown in Table 4.

Table 4. Common denominator metrics for national AMU

Metric	Description	Advantages	Disadvantages
Number of inhabitants	Best estimate of the population covered by the surveillance system	Simple and widely available; enables per capita comparisons	May not reflect actual access to antimicrobials; excludes institutionalized and transient populations
Biomass (kg)	Estimated total weight of the population (e.g. 10 million people × 70 kg = 700 million kg). Used for One Health comparisons of humans, animals and agriculture	Enables cross-sectoral comparisons; useful for integrated AMU analysis	Requires assumptions on average body weight; less intuitive for clinical interpretation

For national surveillance of AMU, denominator metrics for time usually include a time unit, such as days, months or years.

Composite metrics combine several individual metrics, such as for the numerator and denominator, into a single, comprehensive measure. For example, the density of AMU is a composite metric that expresses the quantity of antimicrobials used relative to a specific population size over a given period. This standardizes AMU data, making them comparable among regions, populations and periods. The numerator (quantity of AMU) and the denominator (population size and time) must be for the same period (e.g. the same calendar year or quarter). The quantity of AMU should also correspond to the population that used the antimicrobials. For example, if the data are for a single insurance scheme covering 67% of a population of 1 million (Insured or uninsured) people, the denominator should be 67% of 1 million, i.e. 670 000 inhabitants (*14*).

For national surveillance, the metrics for density of use can include:

- **DDD/1000 inhabitants/day (DID):** Indicates the average number of individuals per 1000 inhabitants on antimicrobial treatment each day. For example, an AMU density of 10 DID can be interpreted as 10 of 1000 inhabitants being treated with antimicrobials daily. Although the data are usually for 1 year, this metric provides average use per day. In reality, there are often marked seasonal variations in antibiotic use, with higher daily use during winter months when (viral) respiratory infections are more common. Furthermore, this assumption does not take into account combination treatments, the limited suitability of DDD for the paediatric population or deviation of the DDD from the prescribed daily dose.
- **DDD/inhabitant per year:** The number of DDD of antimicrobials per inhabitant per year is used as a proxy for the average total exposure of each individual to antimicrobials annually. For example, an AMU of 10 DDD/inhabitant per year means that, on average, each person would receive 10 days of antimicrobial treatment per year. While this suggests that every individual is treated with antimicrobials for 10 days annually, the actual distribution is highly skewed, because many individuals receive no treatment, while others have multiple or extended treatments. As for DID,

this assumption does not take into account combination treatments, the limited suitability of DDD for the paediatric population or deviation of the DDD from the prescribed daily dose.

- **mg/kg of biomass:** The number of mg of antimicrobials used per kg of the population's mass is calculated by dividing the total weight of antimicrobials used by the estimated total weight of the exposed population. This metric is used in a One Health assessment of AMU in all sectors and is designed to account for the "intensity" of AMU, given the large differences in the weight of different species. For information on calculating biomass, see the annual report of the World Organisation for Animal Health (*15*).

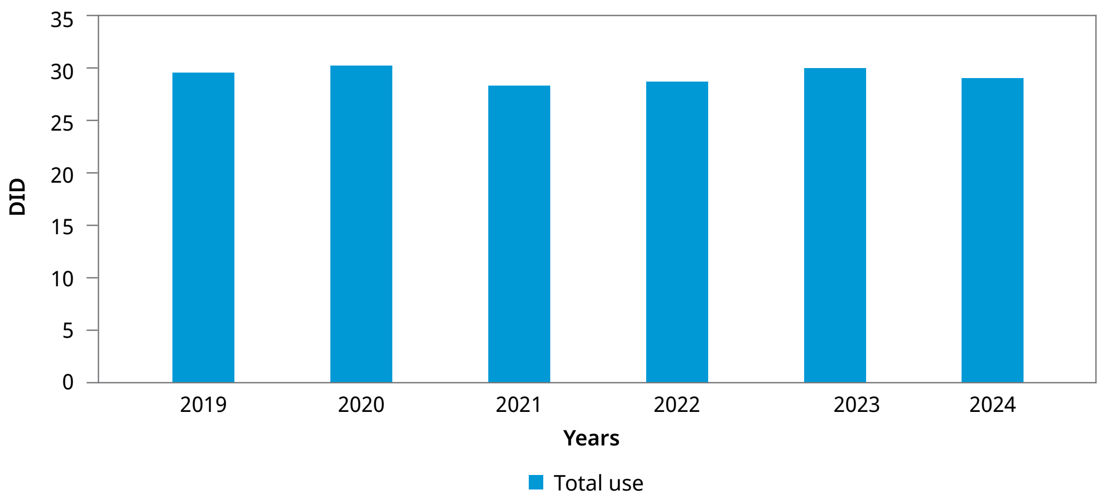
Metrics can be further tailored to better evaluate the appropriateness and impact of AMU. Metrics such as the total number of prescriptions can be used as the numerator; however, to ensure the comparability of settings, standard metrics such as DID should be maintained, as, given the complexity and multifaceted nature of AMU, no single metric can fully capture it. Use of several complementary metrics is therefore recommended when possible.

4.2.3 Key metrics

Total use: Quantity of antimicrobials expressed as DID: This metric is used to measure total national medicine-level use by antimicrobial class (i.e. antibiotics, antifungals, antivirals, tuberculosis medicines and antimalarials). Higher values may indicate potential overuse of antimicrobials, while lower values could suggest underuse or limited access (Fig. 8). WHO has not yet set targets for DID by country. Targets for DID should ideally be based on infectious disease patterns and burden according to the characteristics of the health system. For example, the total AMU in Netherlands (Kingdom of the), a high-income country with effective AMS practices and good access to antimicrobial medicines, is about 10 DID (*16*). This is one of the lowest levels of AMU globally that does not have any major harmful effect on its population due to underuse. Globally, GLASS-AMU surveillance found that, in 2022, the AMU values in 42 countries (70% of those reporting) were between 10 and 25 DID.

Because of methodological limitations, such as differences in data sources, coverage and health-care structures, national AMU data should be compared with caution, although comparisons can provide valuable insights, especially when use is much higher or much lower than in similar countries. The main value of AMU expressed as DID is, however, for monitoring temporal trends in individual countries.

Fig. 8. Quantity of total antibiotic use expressed in DID, country X, 2019–2024



Quantity of antibiotic used as DID and percentages by AWaRe category: In this metric, antibiotic use is broken down by AWaRe category: **Access**, **Watch**, **Reserve** and **Not recommended**. It can be used to identify potential overuse of broad-spectrum antibiotics. **Access** antibiotics are generally the most effective, safe, affordable option for treating common infections. **Watch** antibiotics are broader-spectrum antibiotics associated with a higher risk of resistance, and their use should be limited to clearly defined infections for which the benefit outweighs the risk of resistance. **Reserve** antibiotics are last-resort options for multidrug-resistant infections. **Not recommended** antibiotics are fixed-dose combinations of antibiotics for which there is no evidence of indications and are usually not recommended in high-quality international guidelines (*17*) The AWaRe classification is evolving, however, and a planned revision of the definitions of the different categories will address ambiguities in categorization, clinical applicability and alignment with national AMS practices. Not classified antibiotics are those with no ATC/DDD code that are not (yet) included in the AWaRe classification. In GLASS, they are grouped with Not recommended antibiotics (*18*).

The information on antibiotic use can be presented as DID (Fig. 9) or as a percentage by the AWaRe categories cumulated to 100% (Fig. 10). The two metrics give different information. As shown in Figures 9 and 10, similar relative proportions of use in each category may be found with very different levels of overall use. The political declaration agreed upon at United Nations General Assembly in 2024 calls for at least 70% of total national AMU to be with antibiotics in the Access group (*5*).

Fig. 9. Quantity of antibiotic use by AWaRe category expressed as DID in countries A, B and C in 2024

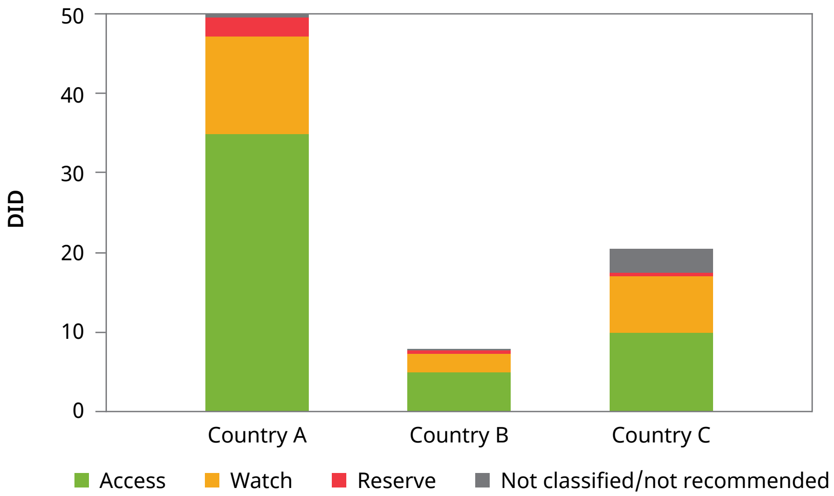
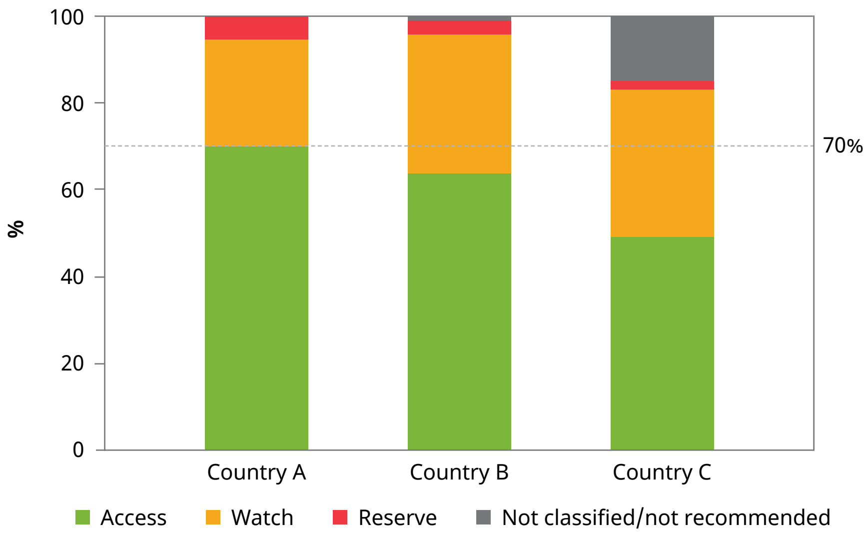


Fig. 10. Quantity of antibiotic use by AWaRe category expressed as a proportion of total AMU in countries A, B and C in 2024



Pharmacy in rural commune health centre, Viet Nam, 2016.

Another AWaRe-related metric is the ratio of Access to Watch antibiotics, which is calculated by dividing the number of DIDs of Access antibiotics by the number of DIDs of Watch antibiotics.

Quantity of antibiotic use as DID and proportion by pharmacological subgroup (ATC3 or ATC4): This metric is used to describe use patterns according to pharmacological subgroup (e.g. penicillins, quinolones, tetracyclines). As in the previous metric, it can be also expressed in DID (Fig. 11) or as a proportion of total use (Fig. 12). Watch antibiotics, which are known to drive AMR, such as quinolones and third-generation cephalosporins, should be a focus of investigation to determine whether their use is appropriate.

Fig. 11. Quantity of antibiotic use by pharmacological class, expressed as DID, in country X, 2022–2024

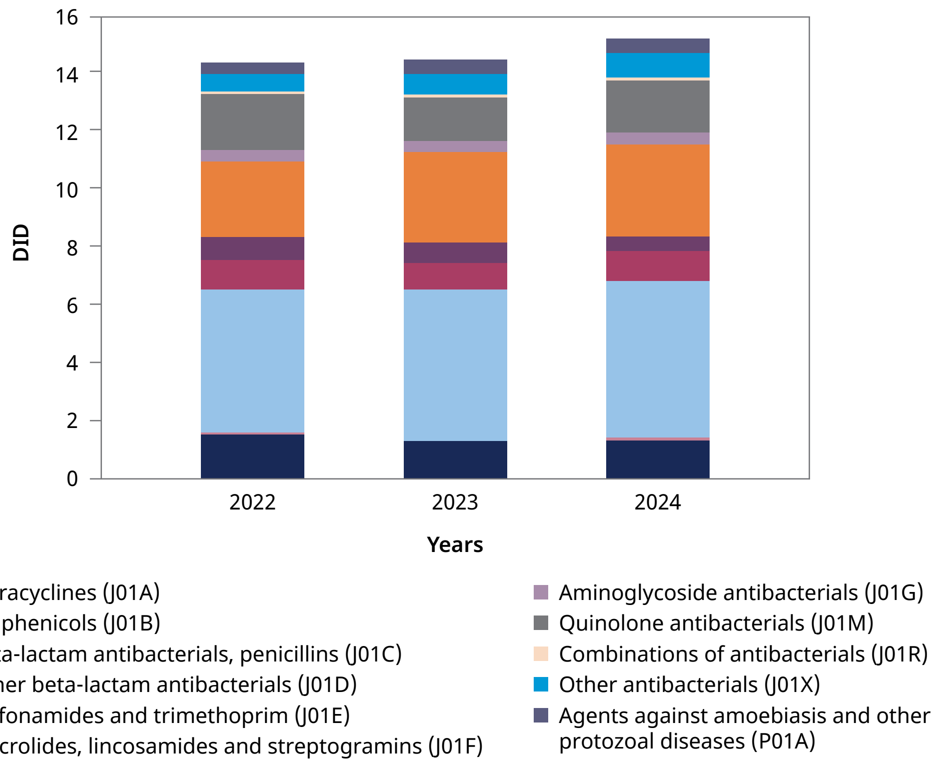
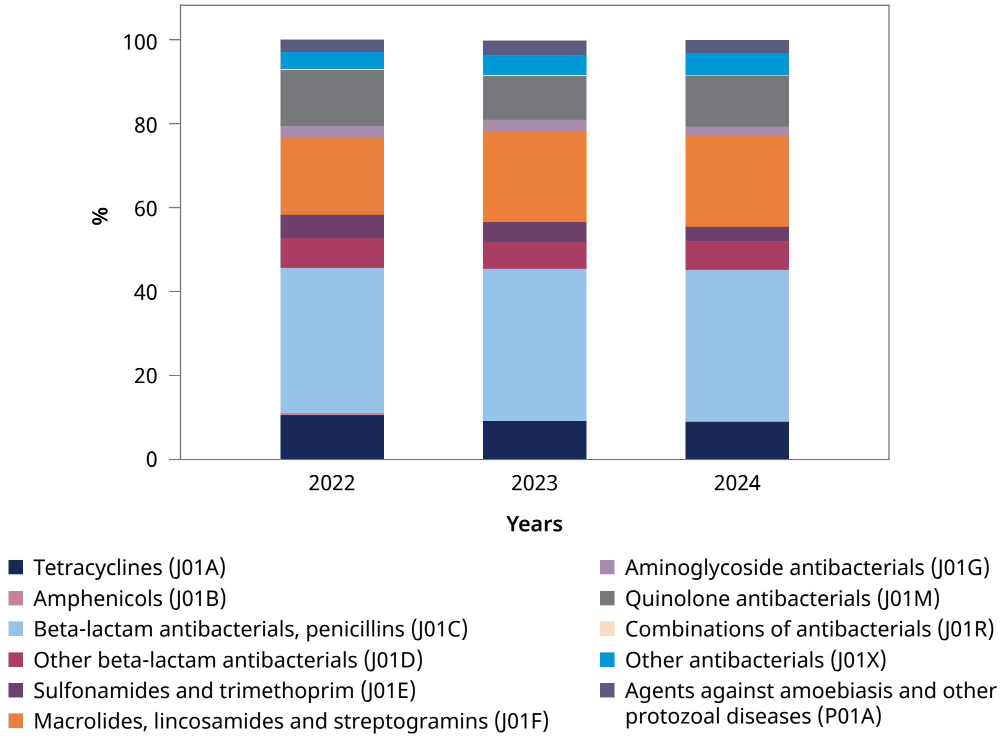


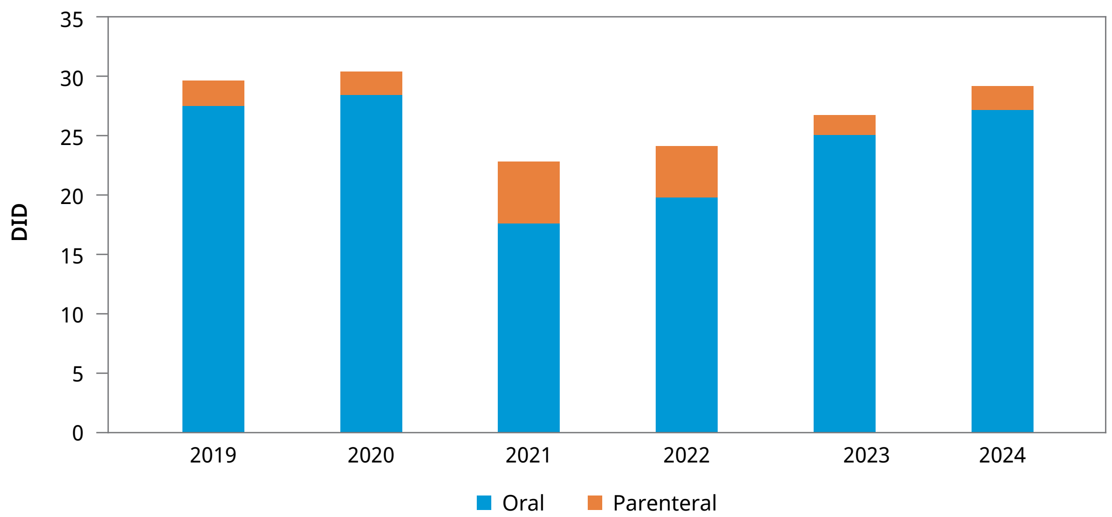
Fig. 12. Quantity of antibiotic use by pharmacological class, expressed as a proportion of total AMU in country X, 2022–2024



Relative DID use of antibiotics as a proportion of total use by route of administration: This metric can be used to identify overuse of parenteral formulations. It can be presented in DID (Fig. 13) or the proportion of total use (Fig. 14).

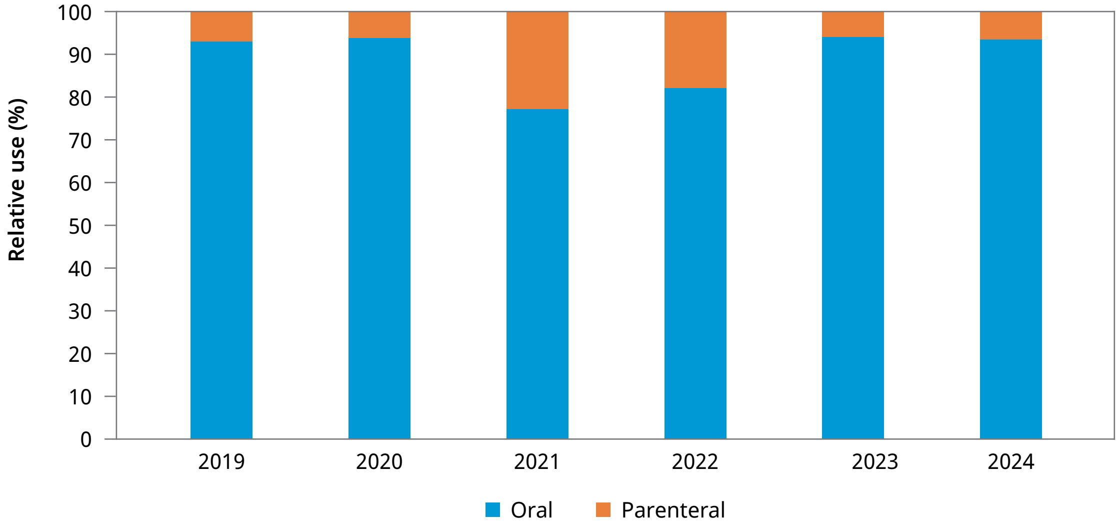
Oral antibiotics are the first-choice treatment for the vast majority of infections in the community and are thus often a good proxy for use in primary care (*17*) In 2022, data reported to GLASS indicated a median proportion of all antibiotic use as 94% oral (range, 62–100%). Lower proportions, such as < 90% oral use, may indicate overuse of parenteral antibiotics in primary care, which is associated with higher costs and a higher risk of adverse effects than oral antibiotics (*7*).

Fig. 13. Quantity of antibiotic use according to route of administration expressed in DID in country X, 2019–2024



Data quality was checked, and no major issues were identified. After further investigation, it was found that the lower overall use and higher parenteral use in calendar years 2020 and 2021 were attributable to the COVID-19 pandemic.

Fig. 14. Quantity of antibiotic use according to route of administration, expressed as a proportion of total use in country X, 2019–2024



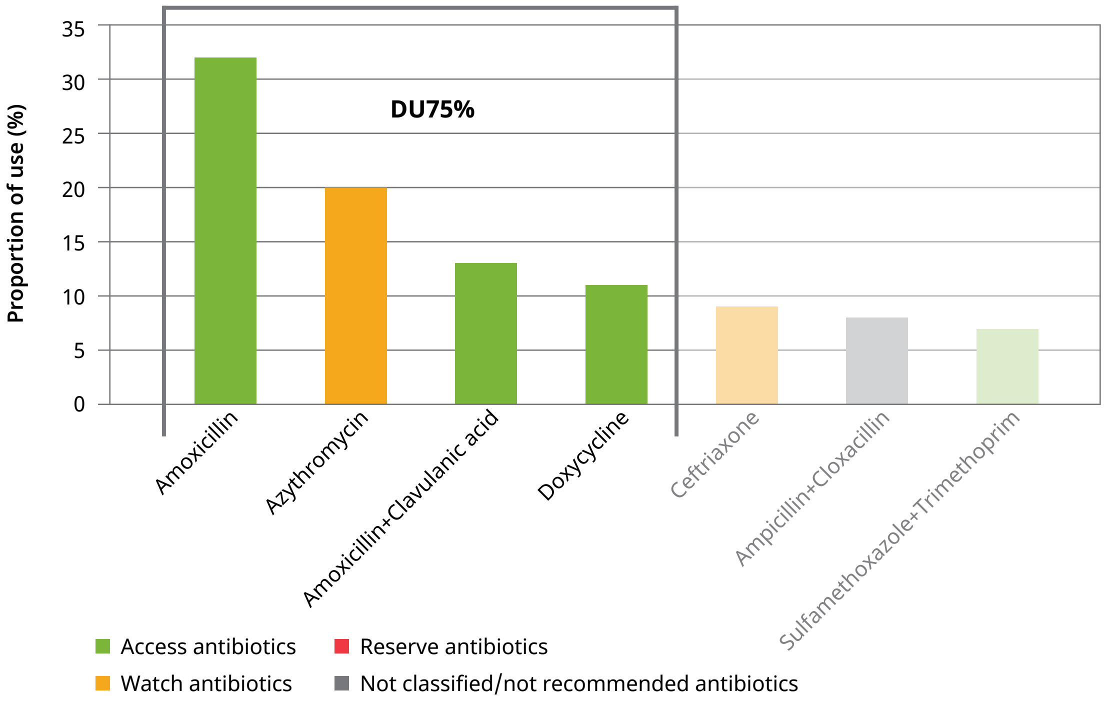
Most frequently used antimicrobials that collectively account for 75% (drug utilization 75 [DU75]) or 90% (DU90) of total use, by route of administration:

DU75 and DU90 are used to identify the antimicrobials that account for most use (Fig. 15), usually measured as DDDs. To calculate DU75 or DU90, all medicines in a group are listed, with their total use, usually measured in DDD. The medicines are then ranked from highest to lowest by volume. The cumulative percentage of total use is calculated, as the DU75 and DU90 for the medicines that together account for 75% or 90% of total use, respectively. These metrics are used to assess the concentration of use and the most commonly used medicines in a therapeutic group. The data can be further stratified by route of administration (*14*).

The number and type of antibiotics in the DU75 or DU90 categories give an indication of the quality of antibiotic use, according to whether they are first or second choice, recommended or not recommended, or Access or Watch. For example, a larger number of antibiotics, especially those that are not recommended, in a national DU75 suggests suboptimal use, because the most common infections can be treated with a few first-line (Access) antibiotics (*17*). Furthermore, comparison of countries may be useful, such as when an antibiotic is in DU75 or DU90 in one country and not in others.

Fig. 15 provides an example in which four of the seven most frequently used antibiotics (amoxicillin, azithromycin, amoxicillin-clavulanate, doxycycline) are in DU75. Of these, three are Access antibiotics (amoxicillin, amoxicillin-clavulanate and doxycycline), and one is Watch (azithromycin).

Fig. 15. Example of DU75 antibiotics grouped by AWaRe category in country X in 2024



Quantity of antimicrobials as weight in mg/kg of biomass for determining total use:

This metric is used to measure AMU with a standard denominator for all sectors, allowing comparison of overall use in humans, animals and plants (Fig. 16). Data are expressed in mg/kg, derived by dividing the total weight of antibiotics by the estimated mass of people or animals in each sector.

Fig. 16. Antibiotic use in the human and animal sectors expressed in mg/kg in country X in 2023

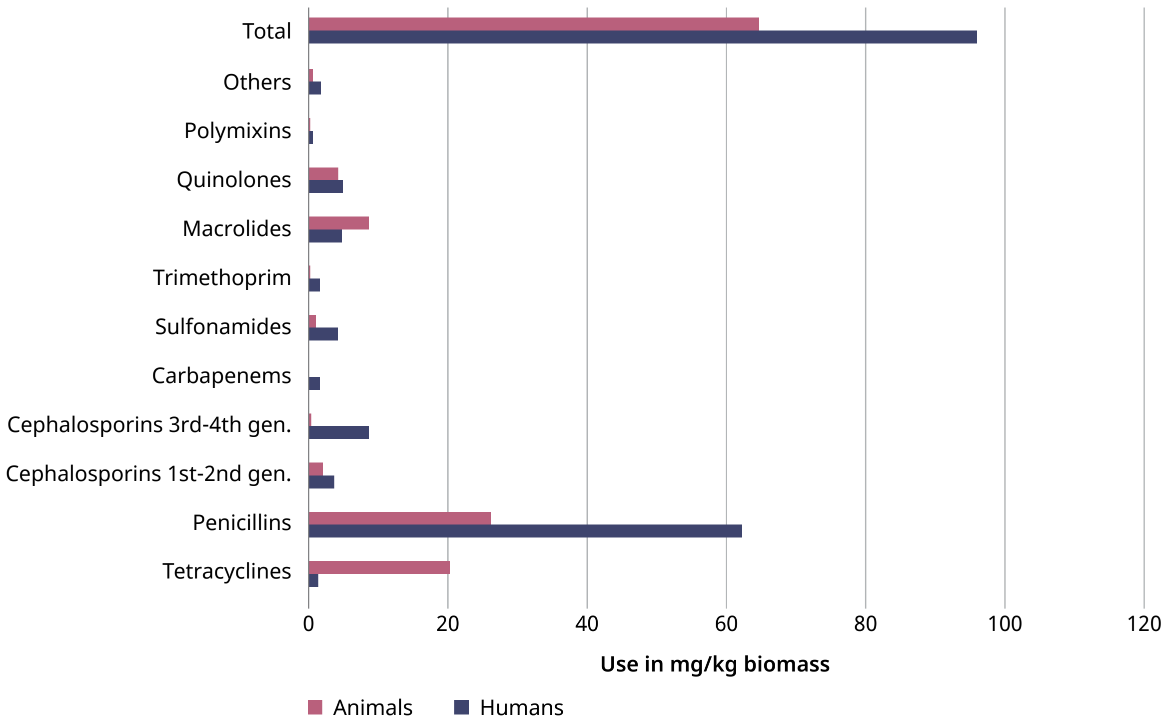


Fig. 16 illustrates differences in antibiotic use by type and total weight relative to body mass in the human and animal sectors. Overall, antibiotic use is higher in the human sector. Among the critically important antimicrobials that are authorized for use in both sectors, quinolone use is comparable, while that of macrolides is notably higher in animals. In respect of the antimicrobials authorized only for human use, carbapenem use is not reported in animals, but polymyxins, such as colistin, are, even though they are last-resort treatments for multidrug-resistant infections in humans. This is a concern and indicates that further investigation is necessary into whether such use could be reduced without compromising animal health. The data also show extensive use of penicillins and tetracyclines, which are classified as highly important antimicrobials for both humans and animals. Although they are not in the highest priority group, their use should be monitored to ensure they are not being used for growth promotion (*19*).

The GLASS manual on management of antimicrobial consumption data contains more details of calculation of the medicine-level use metrics and indicators described above (*14*).

4.3 Analysis of national data

Data analytics for AMU include systematic analysis, interpretation and presentation of data for monitoring and optimizing use of antimicrobials. Key elements include tracking use patterns, identifying trends and assessing the effectiveness of interventions. The aim is to inform policies, improve clinical practice and ultimately reduce AMR by providing actionable information to health-care providers, policy-makers and other stakeholders (*20*).

AMU data are presented in standard metrics and indicators and analysed with descriptive statistics, including frequency measures, counts, proportions (expressed in percentages), means, medians and ranges.

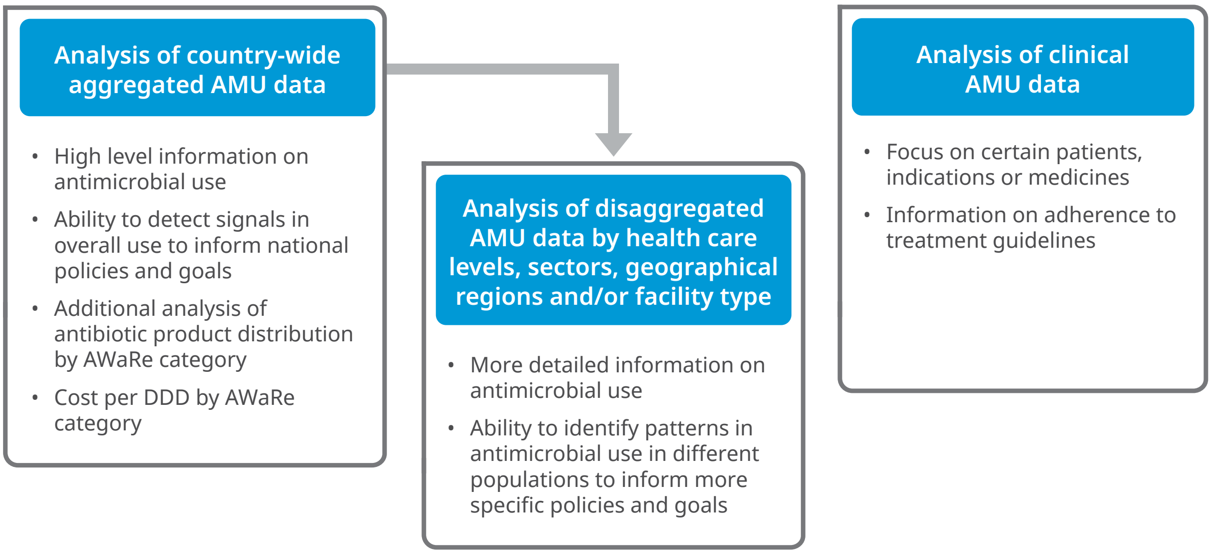
AMU surveillance requires iterative data to set baseline levels of use and to measure changes over time. It may take time to identify changes in AMU data, because the signal (an observed change) must be sufficiently large to be detectable and meaningful. Analysis of time series in AMU data can be used to assess changes after interventions (such as restrictions on use) or after a major event that impacts an entire population (e.g. that of the COVID-19 pandemic on access to health services, including medicines).

AMU data include limited information on how antimicrobials are used (e.g. for what indication, in what populations, for how long); however, they can provide important indicators of low access, inappropriate use or overuse of certain antibiotics, classes or AWaRe groups. Investigation of these signals in targeted surveys or audits can provide additional information to test hypotheses and understand the cause of a problem.

For example, if national data indicate an increase in carbapenem use for two consecutive years over that in baseline years, audits and a detailed review of patient charts are necessary to determine whether the trend is occurring in all hospitals in which carbapenems are used or in only a few. Such audits should indicate the reasons for the increase, such as increased resistance to third-generation cephalosporins in Enterobacterales, shortages or inappropriate use of this group of antibiotics, so that corrective measures can be applied when necessary.

National data should be analysed in steps according to the capacity of the surveillance system to collect increasingly granular data. Fig. 17 summarizes the steps and the scope of data analysis at each step.

Fig. 17. Stepwise approach to increasing capacity for analysing national medicine-level data



4.4 Presenting information

To increase the usefulness of AMU metrics, broader expertise is necessary in data analysis, presentation and interpretation. This will help to ensure that data are understood by the diverse stakeholders involved in health policy and AMS.

Visualization of results in figures, tables, charts, maps or infographics facilitates communication of messages. Presentations of medicine-level data should ensure that users can compare the size of each class or category with that of others and with the total. General tips for presenting data include the following (*21*,*22*):

- Avoid information overload: One table, map or graph should have one main message.
- Ensure readability: Fonts should be sufficiently large and the text limited to essential components.
- The title should include the time, place and national population and the metric used; e.g. National medicine-level antibiotic use in DID in 2025 in country A.
- Clearly label all data elements, including axes.
- Use distinguishable colours and contrasts.
- Avoid three-dimensional graphics, which may look nice but are difficult to interpret.

4.4.1 Tables

Tables are used to present comprehensive data sets by category, setting or time. Tables enable presentation of exact numbers, which can be re-used for further analysis, and of many data points simultaneously in a logical, organized manner. Large tables, however, can be unwieldy and difficult to read, and it may be difficult to draw clear conclusions from such tables, for example to identify trends or patterns. Templates can be used to present data, such as in Table 5 for data on total use and pharmacological subgroups and Table 6 for aggregation by AWaRe category.

The data presented in Table 5 as DID and percentages of total use show that total antibiotic use remained stable between 2022 and 2024 and that penicillins were the class most used. Use of sulfonamides and quinolones decreased, while that of macrolides and penicillins increased slightly, indicating changing prescribing patterns. The data presented in Table 6 as DID and percentage of total use show increased use of Access antibiotics between 2021 and 2023, while use of Watch group antibiotics remained stable and that of Reserve antibiotics remained minimal, indicating alignment with the goals of stewardship.

Table 5. Table showing national antibiotic use by pharmacological subgroup in country X, 2022–2024

Pharmacological subgroup	DDD/1000 inhabitants/day (%)		
	2022	2023	2024
Tetracyclines (J01A)	1.5 (10.55)	1.3 (9.09)	1.3 (8.72)
Amphenicols (J01B)	< 0.1 (0.56)	0.0 (0.00)	< 0.1 (0.27)
Beta-lactam antibacterials, penicillins (J01C)	4.9 (34.46)	5.2 (36.26)	5.4 (36.22)
Other beta-lactam antibacterials (J01D)	1.0 (7.03)	0.9 (6.29)	1.0 (6.71)
Sulfonamides and trimethoprim (J01E)	0.8 (5.63)	0.7 (4.90)	0.5 (3.53)
Macrolides, lincosamides and streptogramins (J01F)	2.6 (18.28)	3.1 (21.68)	3.2 (21.46)
Aminoglycoside antibacterials (J01G)	0.4 (2.81)	0.4 (2.59)	0.4 (2.35)
Quinolone antibacterials (J01M)	1.9 (13.36)	1.5 (10.49)	1.8 (12.07)
Combinations of antibacterials (J01R)	< 0.1 (0.28)	< 0.1 (0.21)	<0.1 (0.13)
Other antibacterials (J01X)	0.6 (4.22)	0.7 (4.90)	0.8 (5.37)
Agents against amoebiasis and other protozoal diseases (P01A)	0.4 (2.81)	0.5 (3.50)	0.5 (3.35)
Total	**14.2 (100)**	**14.3 (100)**	**14.9 (100)**

Table 6. Table showing national antibiotic use by AWaRe category in country Y, 2022–2024

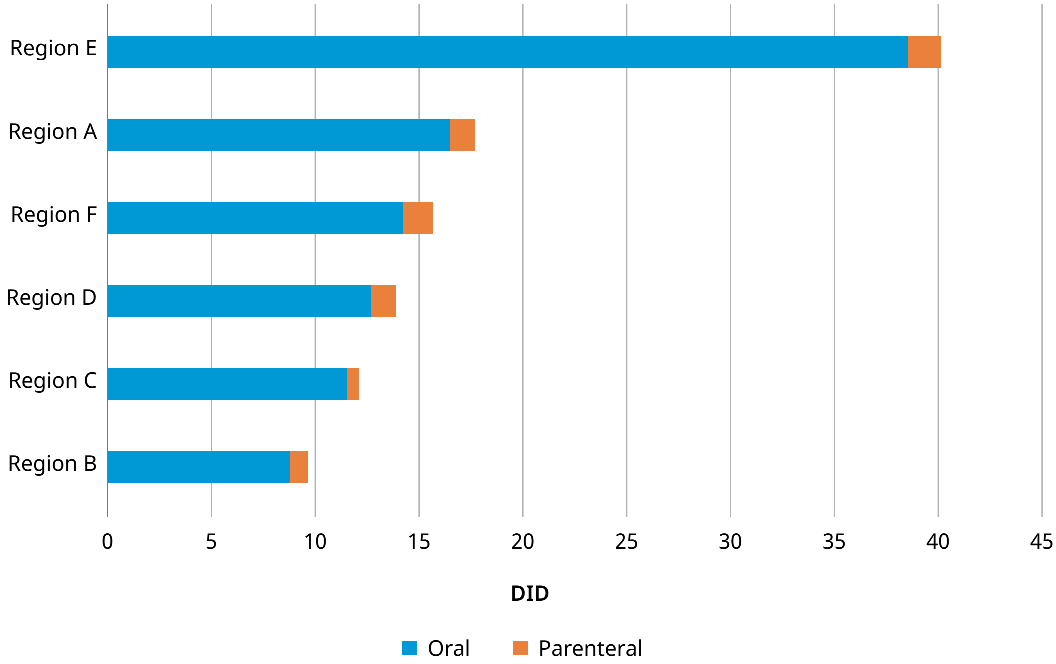
AWaRe category	DDD/1000 inhabitants/day (%)		
	2022	2023	2024
Access	5.70 (57.61)	8.47 (66.72)	8.29 (63.45)
Watch	4.08 (41.30)	4.11 (32.35)	4.7 (36)
Reserve	< 0.01 (0.09)	0.02 (0.47)	0.01 (0.27)
Not classified or not recommended	< 0.2 (1)	0.02 (0.47)	0.01 (0.27)
Total	**10.07 (100)**	**12.62 (100)**	**13.01 (100)**

4.4.2 Bar charts

Bar charts, often in the form of absolute and relative stacked bars, are frequently used to present patterns of AMU in different antimicrobial groups, facilitating comparison of the contributions of groups.

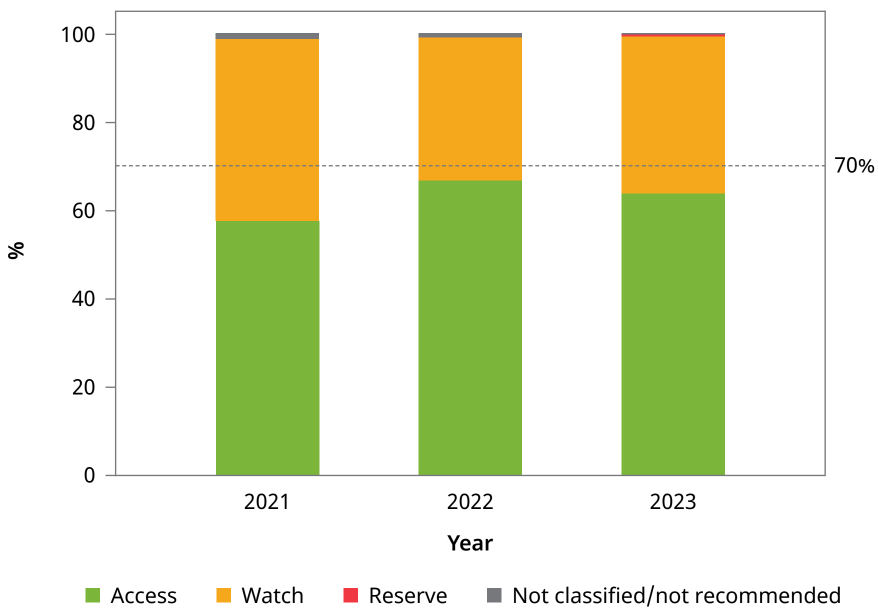
Absolute stacked bar charts present the contribution of each group to the total in various settings and differences in totals among settings. When there is no natural order (such as calendar years), the bars should be horizontal and sorted from the highest to the lowest. Fig. 18 illustrates variation in the oral and parenteral use ratio among subnational regions and their total use.

Fig. 18. Absolute bar chart showing AMU per route of administration and region in country X in 2024



In an absolute bar chart, it is difficult to identify trends in different groups. Furthermore, when the range of total AMU in different settings is not the same, some bars appear flat and unreadable. Relative stacked bar charts address the main disadvantage of absolute stacked bar charts by cumulating the size of the bars to 100% (Fig. 19). Fig. 19 presents the distribution of antibiotic use by AWaRe category in country Y in section 4.4.1. The two types of bar chart provide complementary information and can be used together.

Fig. 19. Relative stacked bar chart showing the proportion of antibiotic use by AWaRe in country Y, 2021–2023



4.4.3 Line charts

Line charts can be used to visualize trends of use over time. They can present several antimicrobial classes or settings simultaneously and increases or decreases in trends over time, as well as short-term peaks or drops due to unexpected events. They are useful for illustrating the effect of an intervention on trends in use (Fig. 20). If a change in data collection affects comparability, the trend line should be broken at the point of change (Fig. 21).

Fig. 20. Line chart illustrating overall use of antibiotics before and after a mass media awareness campaign on antibiotics conducted between November 2015 and March 2016 in country X, 2010–2023

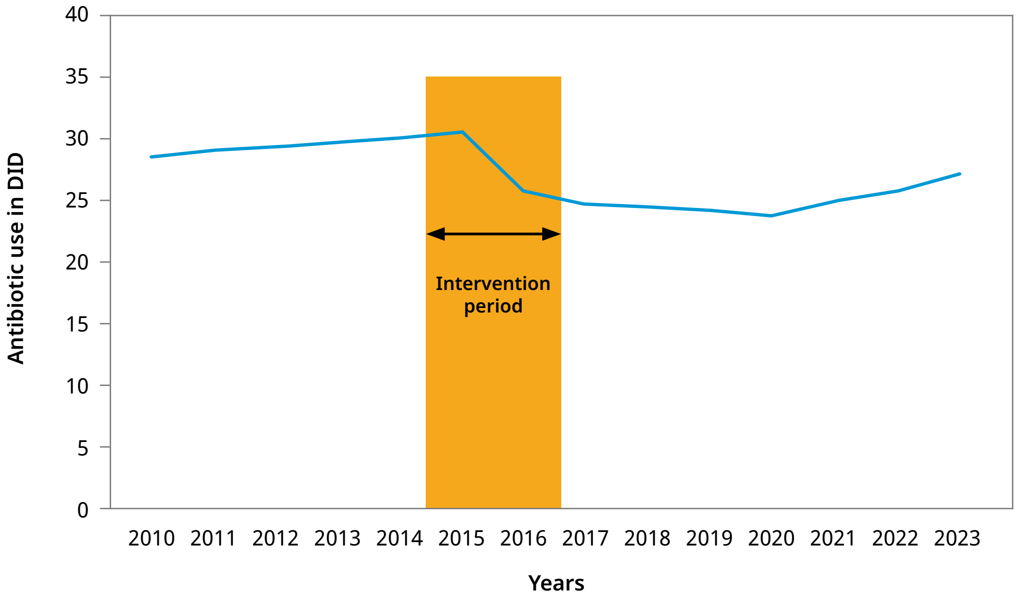


Fig. 21. Line chart illustrating trends in national use of penicillins and macrolides in country X, 2012–2024

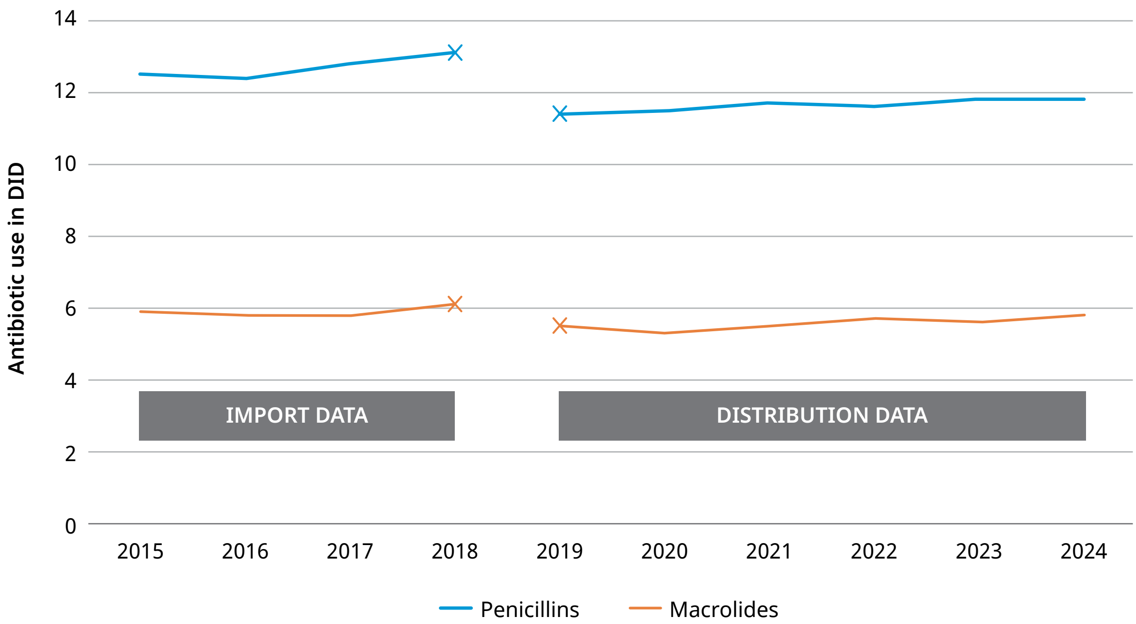
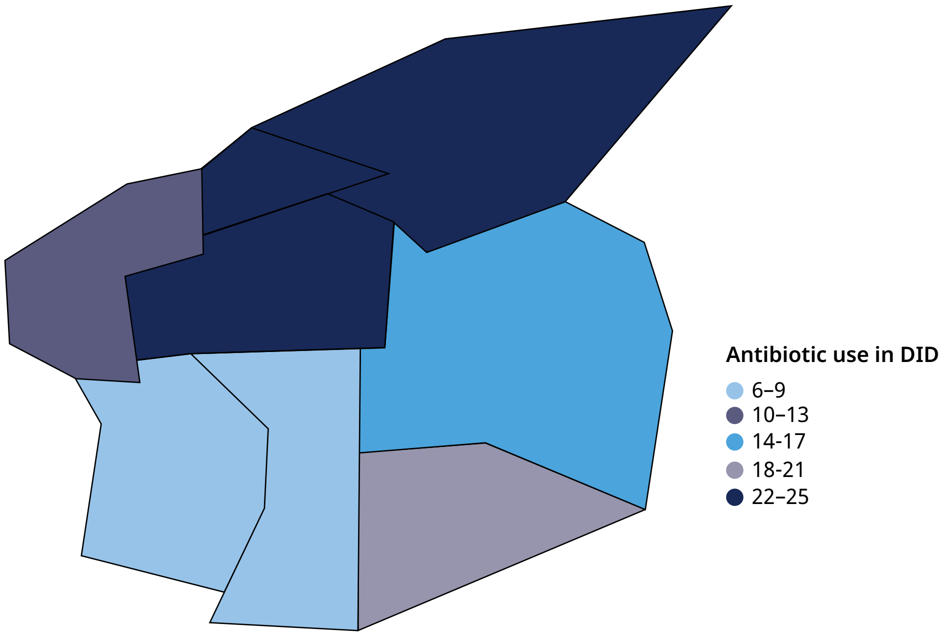


Fig 21 is an example for line chart spanning over two non-comparable periods due to change in data sources.

4.4.4 Maps

Maps are used to illustrate AMU by place, in relation to health infrastructure (e.g. hospitals), epidemiological data (e.g. outbreaks) or socio-economic and geographical determinants. Maps illustrate subnational variation in a country from data collected subnationally. Geo-referenced data (e.g. latitude and longitude) may be necessary to place points accurately on a map. Use of maps requires specific tools such as geographic information systems and sometimes advanced statistical tools. In the context of AMU, maps can be used to report use in areas (e.g. county, region, country) or settings (e.g. health facilities). In the first case, a choropleth, a colour-shaded map, is used (Fig. 22) to present the level of use of antibiotics in different subnational regions, with a continuous or categorical colour gradient.

Fig. 22. Choropleth map showing antibiotic use in country Y expressed in DID per region, 2024



In this hypothetical country, the north-eastern regions have much higher antibiotic use than the south-western regions. The reasons for such intra-country differences should be investigated, as they may due to difficulty in accessing health care. For instance, the north-eastern regions may be densely populated with many urban centres, while most of the south-western regions may be rural. Common factors include differences between rural and urban areas, differences in physician or pharmacy density and socioeconomic factors. More detailed interpretation of intra-country differences are illustrated in the example in Box 8 in section 5.

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5 Interpreting information

Reaching people at risk of malaria in remote areas of Chhattisgarh, India, 2023.

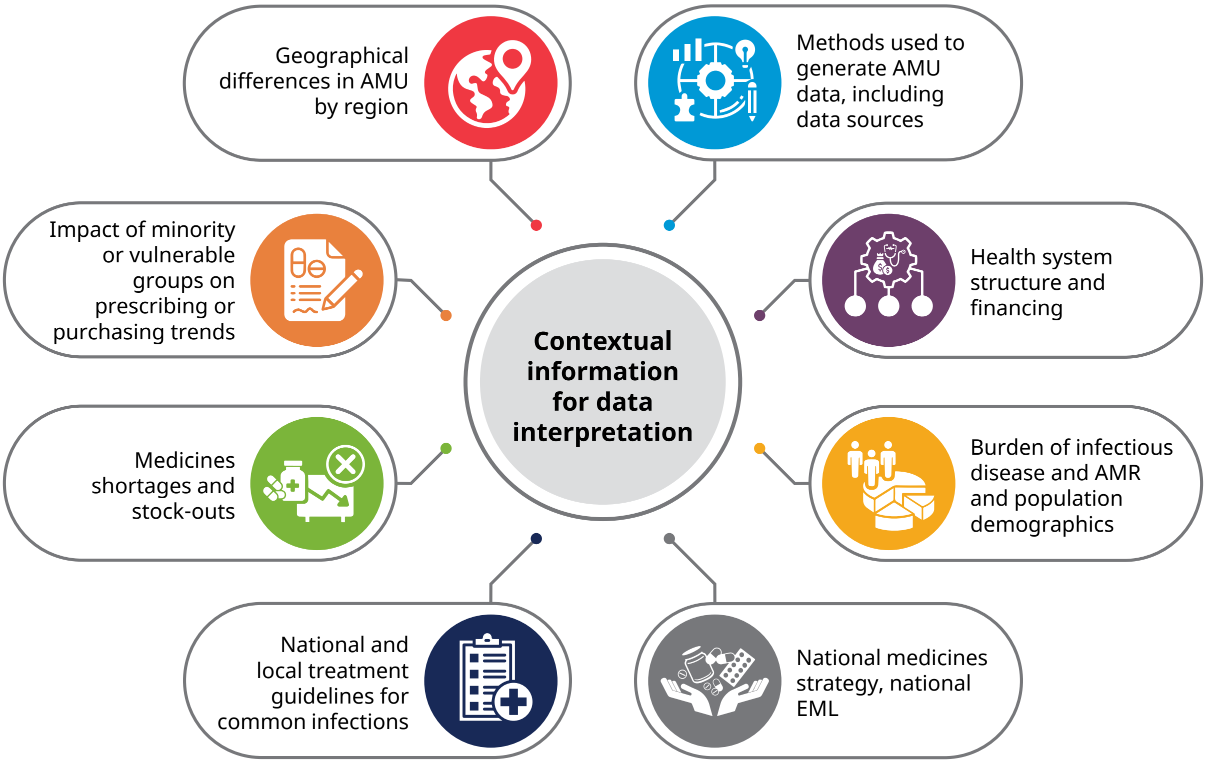
Data interpretation consists of analysing and drawing meaningful conclusions from data to transform raw data into actionable insights for decision-making, to support hypotheses or to guide problem-solving. Effective data interpretation requires both analytical skills and domain-specific expertise to ensure accuracy and to avoid misrepresentation or bias.

Given the complexity and cross-sectoral relevance of AMU, it is essential that interpretation be conducted by a multidisciplinary group of experts. The group should be mandated to interpret the results of analyses, develop national AMU reports, formulate recommendations to improve national use and, when appropriate, to propose improvements to the AMU surveillance system.

Interpretation of AMU data includes consideration of all the factors that influence the data, including prescribing, dispensing and patient use of medicines, and external factors such as the availability and affordability of medicines and the characteristics of the health-care and surveillance systems. As interpretation of AMU patterns requires consideration of such contextual information, it should be collected at the same time as data on AMU (23).

The following contextual information may be relevant for data interpretation:

Fig. 23. Contextual information for data interpretation



- **Methods used to generate AMU data, including data sources:** Some sources of data have limitations. For example, import data may include expired medicines; insurance data may not include non-reimbursed antibiotics. (See also Fig. 6.) Any changes in methods that might limit comparisons of data over time should be identified, such as a change from procurement to dispensing data or import to distribution records as in Figure 21.
- **Health system structure and financing:** Antibiotics that are reimbursed can be expected to be used more often than those that are not. The list of reimbursed medicines (and the national EML) will influence patterns of AMU. The frequency of OTC sales of antimicrobials should also be

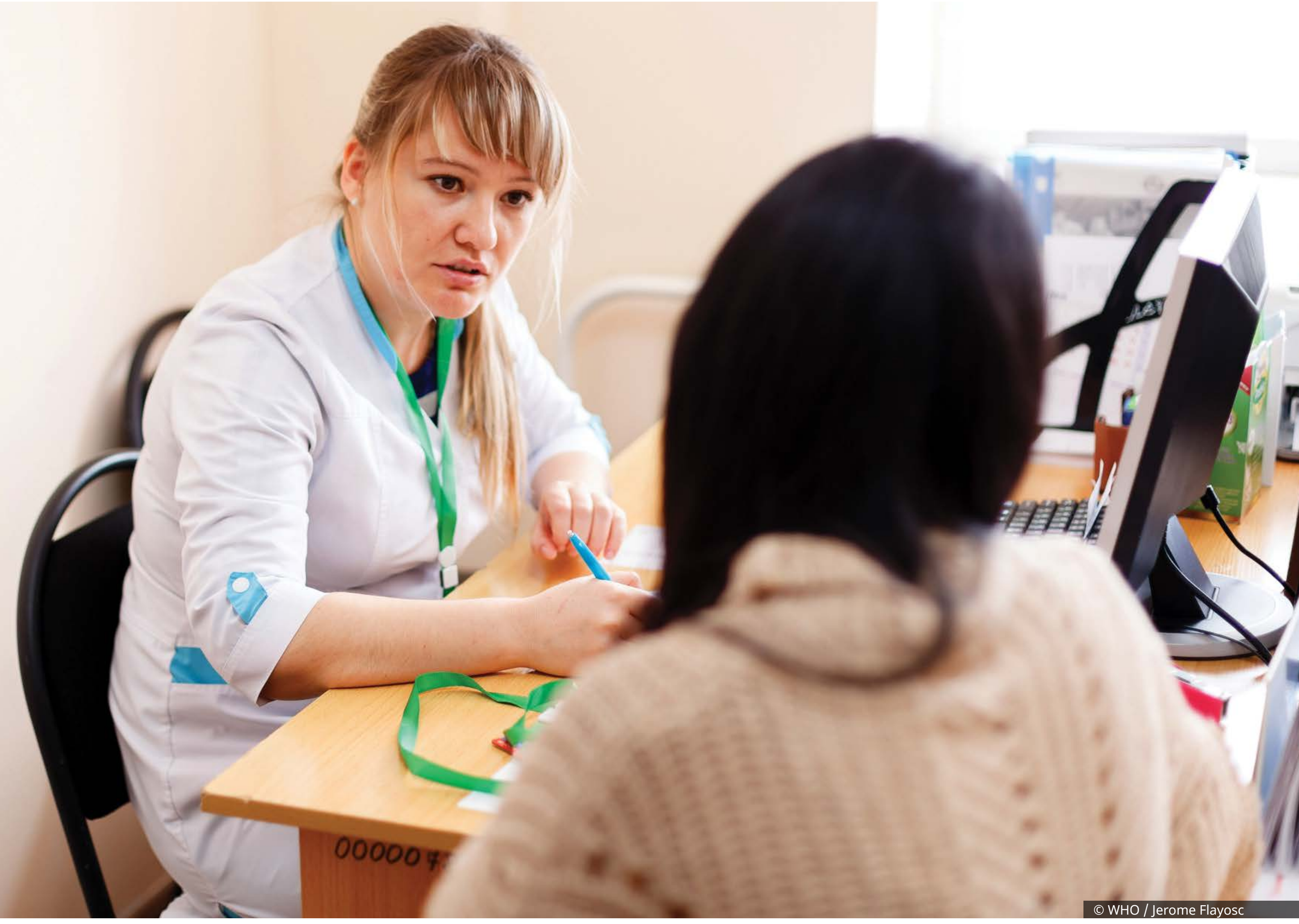
considered. If they are frequent, mechanisms should ideally be in place to capture data on OTC (e.g. through pharmacy reporting systems, sales audits or digital tracking platforms). The volume of OTC sales of antibiotics may depend on factors such as regulation, financial incentive, price, personal reasons (e.g. perception of effectiveness of an antibiotic, access to a doctor) or a recommendation by a pharmacist. OTC AMU, which may represent a substantial share of total use in many low- and middle-income countries, is often poorly captured because of weak enforcement of regulations on prescriptions and gaps in data infrastructure.

- **Burden of infectious disease and AMR and population demographics:** In settings with a high burden of bacterial infections, due, for instance to limited access to safe drinking-water, sanitation and hygiene, infection prevention and control and vaccination, the overall volume of antibiotics used is expected to be higher. Use of certain antibiotics (e.g. Reserve antibiotics) in settings in which infections due to multidrug-resistant pathogens are more prevalent may also be higher. In reality, however, there is often a disconnect between the availability of Reserve antibiotics and the burden of multidrug-resistant pathogens, as countries with the highest burden of such pathogens have the least access to Reserve antibiotics, especially the newer, more expensive ones. Use of vancomycin can be used as a marker of methicillin-resistant *Staphylococcus aureus* infections, although the level of use that is appropriate or expected in such contexts is unknown.
- **National medicines strategy, national EML:** As medicines on the national EML are prioritized for public sector procurement, the list influences AMU patterns in a country, at least in the public sector. Examination of AMU according to inclusion on the national or WHO EML will address this issue.
- **National and local treatment guidelines for common infections:** Guidelines provide recommendations for the indications for AMU and first-choice treatments, including situations in which antimicrobials should be avoided to prevent unnecessary use. Such guidelines influence patterns of antibiotic use. Alignment of the guidelines with the national or WHO EML and international guidance such as the WHO AWaRe antibiotic book (*17*) and the WHO guidelines can be used to assess the consistency and effectiveness of treatment protocols. AMS programmes and activities can improve problematic antimicrobial use. When interpreting antibiotic use data, it is important to consider the context of current treatment guidelines. For example, a recent update may recommend antibiotic X at a higher dose for common infections or replace a previously used antibiotic with antibiotic Y, which could explain changes in use patterns, such as a change in first line treatment for lower urinary tract infections from ciprofloxacin to nitrofurantoin.
- **Medicines shortages and stock-outs:** This indicator is used to track the availability of medicines, indicating when medicines are in short supply or totally unavailable. Shortages can be due to various factors, including manufacturing issues, supply chain disruption, regulatory challenges and increased demand. Monitoring of shortages and stock-outs is crucial to ensure continuous access to essential medicines. For example, during a shortage of antibiotics, health-care providers may have to adjust treatment protocols by switching from first-choice Access to Watch antibiotics, potentially resulting in suboptimal care and increased AMR. Shortages or stock-outs of medicines are, however, often underreported because of a combination of factors, including limited surveillance systems, lack of standardized reporting, fear of reputational damage of suppliers or facilities and insufficient awareness or training of health-care workers on the importance of reporting. For example, country X experienced a shortage of amoxicillin (Access antibiotic) due to global supply issues. This was reflected in a decrease in amoxicillin use and an increase in azithromycin (Watch antibiotic) use, presumably used by prescribers as an alternative antibiotic.
- **Impact of minority or vulnerable groups on prescribing or purchasing trends:** The presence of minorities or vulnerable groups in an area can influence how antimicrobials are prescribed and purchased. Such groups often face disparities in access to and the quality of health care, which can result in differences in medicine use. For example, some minority communities may have lower rates of appropriate prescriptions of antimicrobials due to barriers such as poorer access to health

care, low socioeconomic status, their cultural beliefs and language barriers. These can result in under- or inappropriate use of antimicrobials, potentially contributing to poorer patient outcomes and higher rates of AMR. Recognition of these dynamics can result in addressing health inequities and ensuring equitable access to antimicrobials. Furthermore, vulnerable groups are often treated with donated medicines. As outlined above, donated medicines are sometimes not systematically recorded in official reports, leading to underestimation of use in these populations.

- **Geographical differences in AMU by region:** Differences in AMU by region are due to various factors, which are not always fully understood. Contributing elements may include cultural attitudes (e.g. a tendency to seek medical care for mild illnesses); health system structure, including density of physicians and pharmacies (higher density often being associated with higher use); demographic differences (e.g. a large proportion of young children or the elderly may be associated with higher use, as these age groups have the highest burden of infectious diseases); socioeconomic factors (e.g. rural areas are often poorer and have less access to health care); regional epidemiology of infectious diseases (e.g. malaria may be more prevalent in certain regions); and differences in the prescribing behaviour of health-care workers.

While interpretation of national medicine-level data is context-specific, some general considerations can be identified (Box 6).



Primary Health Care in Kazakhstan, 2019.

Box 6. Considerations in interpreting national data on medicine-level AMU

Consider the following questions when interpreting national medicine-level AMU data.

- Are there any unexpected results (e.g. large annual changes in overall use of certain antimicrobials)? Do the changes reflect true changes in use, or have there been changes in practice (e.g. regulatory, policy or political changes, new medicines on the market or new guidelines, disease outbreaks, medicine shortages and stock-outs or new surveillance methods) or issues related to the quality of the data or their analysis?
- Does the pattern of use provide insights about AMU in the country for the given period? Is there an increase in the use of Watch and Reserve antibiotics, potentially suggesting an increase in resistant infections? Or does the trend suggest overprescribing or changes in local manufacturing or the import of medicines?
- What are the trends in the indicators measured in the country and how do they compare with the baseline and over time? Are the trends moving in the right direction or on track (for countries with defined targets or goals) or to meet the global target of use of 70% Access antibiotics?
- How do the national AMU data compare with those of other, similar countries or those in the same region? Are there any issues with data validity or completeness? If the data are valid and complete, much higher use than in other countries may indicate widespread overuse of antibiotics. Much lower use than in other countries may raise the question of whether access to antimicrobials is problematic.

Consider collecting more data.

- Which areas of AMU should be further investigated? For instance, if there is high parenteral use, investigate where it occurs, and potentially follow up with point prevalence surveys or audits to better understand whether use is inappropriate or whether there are other explanations.
- What actions can be taken to enhance the quality of the data? Should the choice of data sources be reconsidered; how can data completeness be improved? For example, can import records be digitized, ATC codes added or reporting of data to the ministry of health be made mandatory?

Consider interventions:

- Which areas of AMU should be improved, and which are the main priorities (e.g. those that are considerably below expectations or have important implications for cost or AMR) or “low-hanging fruit” (little effort and high impact)? Examples include surgical prophylaxis practices in terms of use of first-line antibiotics and duration of prophylaxis, unnecessary antibiotic prescribing for viral upper respiratory infections.
- What actions could be taken to improve the identified priorities? Consider entry points at the stages of selection, procurement, distribution, prescribing, dispensing and patient use.

Countries should be aware of and disclose all potential limitations to the method and the quality of data in their surveillance systems to prevent misinterpretation and invalid comparisons among settings and over time. Erroneous results and misinterpretation of surveillance data can lead to inappropriate interventions.

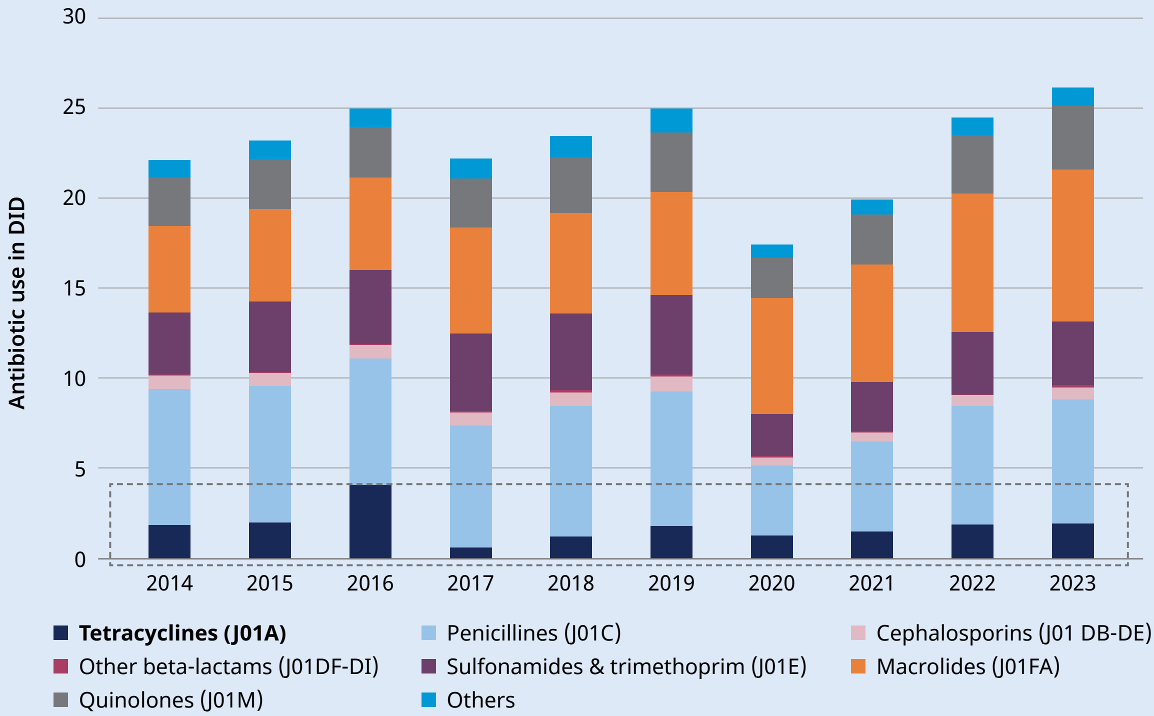
Two examples of data interpretation are presented in Boxes 7 and 8 and Fig. 24.

Box 7. Data interpretation for total and relative use of antibiotics

Low-income country A collects national AMU data from procurement records in the private and public health care sectors. Policy-makers questioned the trend between 2014 and 2023:

- Why was use of antibiotics (specifically tetracycline) higher in 2016 than in previous years? Did the incidence of infections change, or are there errors in the data?
- Why was use of antibiotics lower in 2020 and 2021 than in other years? Is the difference real, or is it an artefact of the data?

Fig. 24. Trends in use of tetracyclines and other antibiotics 2014-2023



High use of tetracycline in 2016: In 2016, use of **tetracyclines** was nearly double that in 2014 and 2015 but was low in the subsequent 2 years, returning to the 2014 level in 2019 and remaining constant until 2023. What was the cause of the peak in **tetracycline** use in 2016?

☛ In 2016, country A experienced a cholera outbreak. **Tetracycline** is the first-choice antibiotic for treating cholera. In that year, country A procured more **tetracyclines** and received donations, which resulted in the peak in use. The outbreak ended in late 2016. In 2017–2018, the large stock left over from 2016 reduced the need for further procurement. The low use in 2017–2018 therefore reflects the use of stocked medicine.

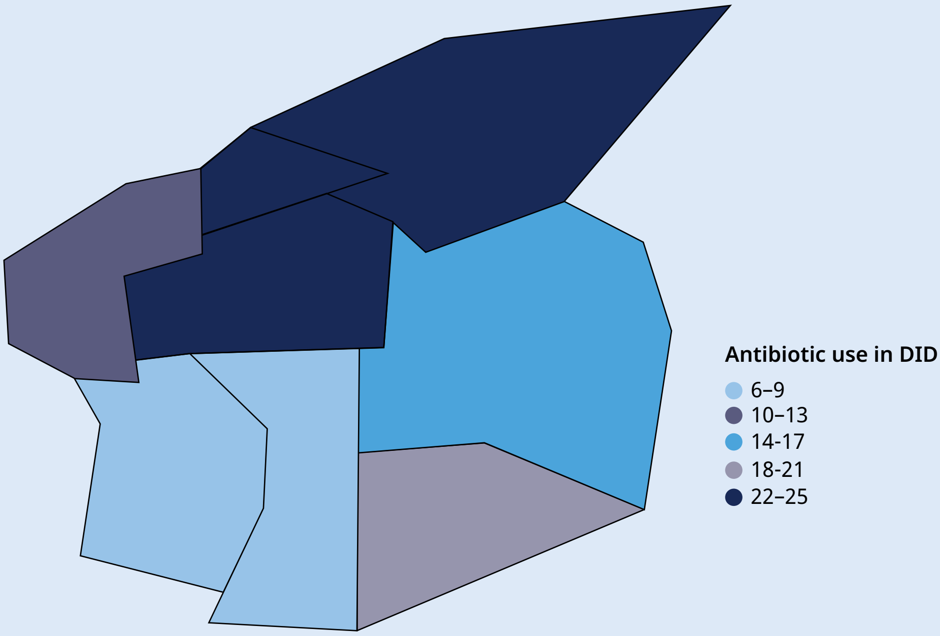
Less use in 2020–2021: Overall, antibiotic use decreased in 2020 and 2021, returning to the 2019 level in 2022 and 2023. Although use of all antibiotic classes decreased, that of macrolides increased and remained at higher levels thereafter.

☛ In 2020–2021, country A experienced the COVID-19 pandemic. In 2020, its borders were closed, making it difficult to procure medicines from abroad. The spread of common community infections and access to prescribers was limited by lockdowns, which reduced the availability, access to and need for antibiotics, which explain the decrease in use in 2020–2021. In 2022, antibiotic use returned to pre-pandemic levels. Macrolides, particularly azithromycin, were inappropriately used to treat COVID-19 and continued to be used more frequently thereafter.

Box 8. Data interpretation for determining geographical patterns of antibiotic use

High-income country B collects data on national AMU from distributors and wholesalers. The data for 2023, analysed at subnational level, indicate a south–north gradient in antibiotic use (Fig. 25).

Fig. 25. Total antibiotic use per region, 2024



The geographical distribution of antibiotic use in country B may be explained by:

- a colder, more humid climate in the north, which could result in more frequent respiratory tract infections, and
- a denser, wealthier, older population in the north, which could result in a higher disease burden, more health services, including more pharmacies, and greater affordability.

Climatic and socioeconomic factors do not, however, always predict antibiotic use consistently. In many European countries (e.g. France and Italy) and in the warmer southern regions of the USA, higher antibiotic use is often reported, suggesting that other factors, such as prescribing practices, cultural norms and access to health care also play significant roles.

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6 Disseminating information

Strengthening PHC in Emergencies: Sub-Regional workshop in Estonia, 2024.

6.1 Identifying audiences

Once AMU data have been collection, analysed and interpreted, the results should be disseminated to all relevant stakeholders to inform policies and practices. These people should have been involved from the start in drafting the relevant research questions that should be answered by surveillance. An accurate presentation, tailored to each audience, will improve the effectiveness of feedback. The target groups include:

- health-care providers;
- policy-makers;
- the national AMR committee;
- the technical working group on appropriate use of antimicrobials;
- the public, patients and consumers;
- media; and
- surveillance groups working in the animal, agricultural and environmental sectors.

6.2 Tailoring the approach

Sharing information requires resources and infrastructure. A stepwise approach can optimize use of resources.

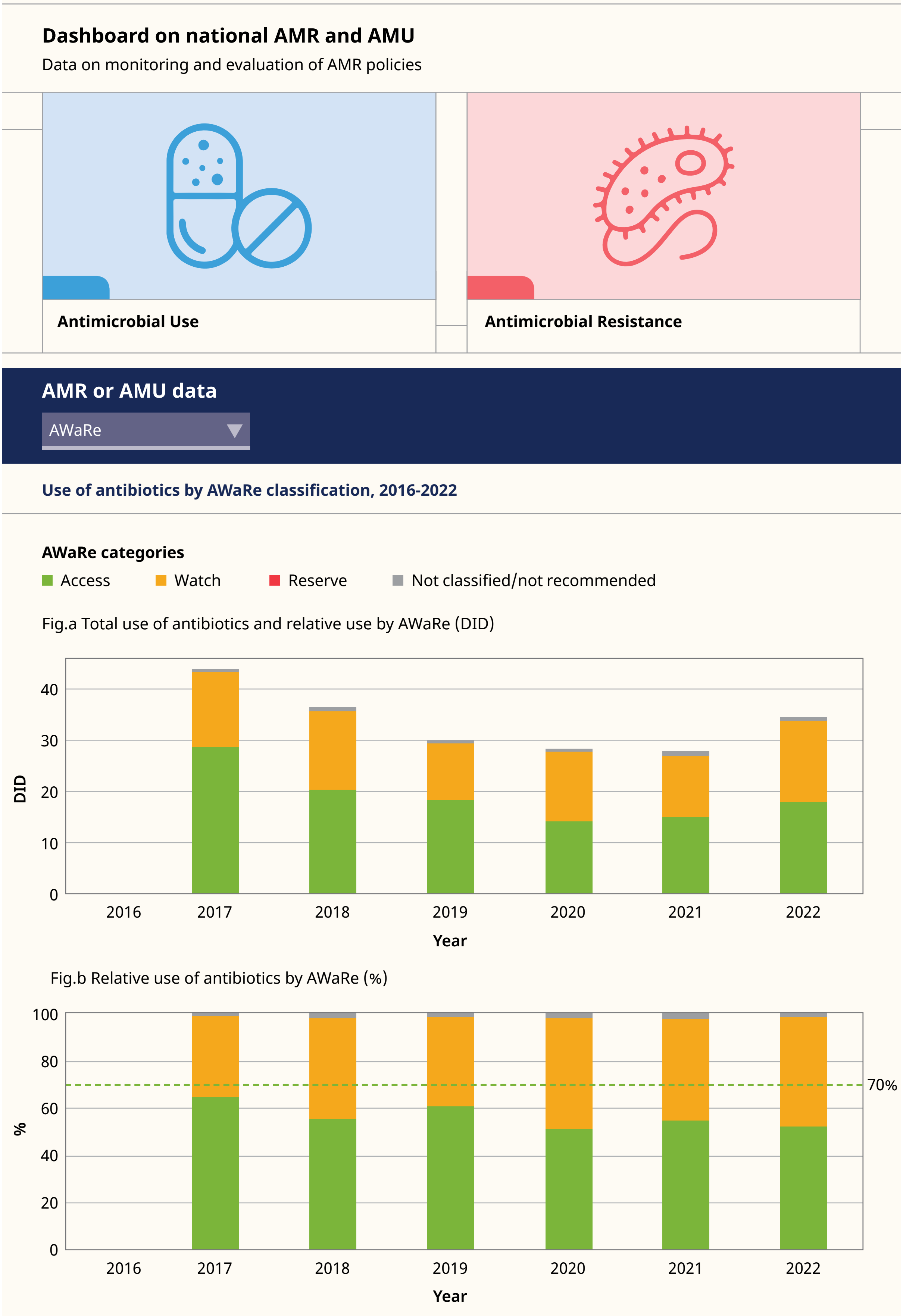
Reports: At a minimum, annual or biannual reports of key trends and patterns could be published. When resources allow, reports could be generated automatically by the responsible national surveillance body and shared via email or newsletters with all relevant stakeholders. The release of a report could be followed by workshops or training sessions for health-care workers and other stakeholders to support interpretation of the findings and strengthen implementation of the recommended actions.

Interactive dashboards: A dashboard is a user interface that displays key metrics and data in an easily digestible format, often in charts, graphs and tables. To enhance the dissemination and use of data, interactive IT dashboards could be developed to include filters for different antimicrobial groups, periods and geographical regions, facilitating identification of trends and areas for attention. Dashboards are designed to provide real-time information to facilitate decision-making by presenting organized information clearly. Health surveillance dashboards for tracking AMU are a good example. They may be public or internal, ensuring timely reporting and enhancing use of data for action (*24*).

Integration into national health information systems: Ultimately, the standard for reporting national medicine-level data is their inclusion in health information systems to group the data on a single, accessible platform. The platform should provide a high-level overview, with options for more detailed displays according to the goals or topics. It should also allow visualization of data in real time (Fig. 26).

Integrating a surveillance module for AMU into health information systems, such as the District Health Information System 2 (DHIS2), involves setting up data entry forms to capture information on AMU. Linking these data to other health data in DHIS2 enables comprehensive monitoring and real-time insights, supporting effective decision making. Efforts to link AMU data with DHIS2 are just beginning, marking an important step towards enhanced surveillance and management of AMR. Relevant experiences from other areas include that of Burkina Faso, where malaria data were integrated into DHIS2, and Somalia, where a DHIS2-based application was used to digitize pharmacy stock management throughout the national supply chain (*25*,*26*).

Fig. 26. Example of a platform displaying national AMR and AMU data in country X



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7 Using information to guide policies and AMS

Strengthening PHC in Emergencies: Sub-Regional workshop in Estonia, 2024.

7.1 Overview

7.1.1 Domains of use of data to guide policy

Surveillance systems provide timely information to decisionmakers. Medicine-level data on AMU are valuable for:

- describing patterns of use and changes over time, including signals of inappropriate use that can be explored further with clinical data;
- assessing whether access to antimicrobials is adequate;
- guiding the design of interventions to address the problems identified, including regulations, selection, supply chain, access to and use of antimicrobial medicines;
- monitoring and assessing the impact of interventions at all levels; and
- raising awareness among health professionals, consumers and policy-makers of the problems associated with inappropriate use of antimicrobials, including AMR, and poor access to antimicrobials.

7.1.2 Utility of information by level of use

Data from surveillance are used to guide strategic decisions by indicating where work should be focused according to the level at which AMU is measured (national, subnational or facility). National data can reveal broad trends in AMU and AMR, while subnational and facility data offer more detailed insights, such as simultaneous overuse of certain antibiotics and limited access to others. For example, in countries where antibiotic overuse is widespread, interventions may be conducted to reduce overall AMU while ensuring that essential antibiotics remain accessible to specific populations, levels of care or geographical regions (27).

7.1.3 Implications for policy, regulations and clinical care

National AMU surveillance also provides insights into the standards of regulatory systems, policies and clinical care. It can reflect the presence and implementation of core policies, such as national antimicrobial treatment guidelines, AMS guidelines, formularies to guide procurement and prescribing, alignment of the national EML with treatment recommendations and the AWaRe principles, and the content of lists of antibiotics that are reimbursed to determine which medicines are covered financially and thus influence prescribing behaviour. Such data capture changes in practice, such as registration of new classes of antimicrobials, introduction of lists of restricted antibiotics and use of AWaRe Not recommended antibiotics, thus indicating further action. Data may also prompt countries to review their broader regulatory frameworks, services and pharmaceutical supply chains beyond antimicrobials, in a spillover effect that can potentially address deficits and strengthen the pharmaceutical system for all medicines (28). National AMU data, however, cannot be used to assess adherence to treatment guidelines, as they do not cover clinical decision-making or patient behaviour.

7.2 Using information to optimize use of antimicrobials

National surveillance should provide nationwide estimates to guide policies for optimal use of antimicrobials. Ideally, data should be presented as both aggregated national figures and disaggregated by health-care sector and/or by region (29). National medicine-level data can inform policy-making for optimal use of antimicrobials, including to:

- develop and monitor progress to achieving national goals to optimize AMU,
- evaluate and strengthen national regulatory procurement and supply systems,
- evaluate concordance with the national medicines policy and
- contribute to regional and global evidence bases on AMU.

7.2.1 Monitoring progress in AMU

In national action plans on AMR, countries may establish goals or targets for total AMU and for use of specific antimicrobial classes or AWaRe categories. As of 2025, the only international target was the goal set by the United Nations General Assembly in 2024: for at least 70% of national antibiotic consumption to be of antibiotics in the Access group (*5*). For all other indicators, countries are expected to define context-specific targets that reflect national priorities. The targets should be meaningful, measurable and aligned with broader AMR strategies. Development and operationalization of such targets is, however, complex and requires substantial additional work, including development of technical guidance, pilot-testing in diverse country contexts and international consensus on definitions of indicator and data interpretation frameworks.

For interpretation and benchmarking, countries are encouraged to compare their AMU data with information reported to WHO GLASS. The GLASS dashboard provides access to data from all reporting countries, so that users can identify relevant comparators, such as (neighbouring) countries with similar health systems, data sources or demographic profiles, and apply the insights where appropriate (*24*).

Table A.1 in the Annex summarizes how key elements of national AMU data can be used in setting and tracking AMU goals. It presents examples of core indicators for AMU, supporting datasets, common biases in data, the actors involved in data collection, reporting and analysis and recommended actions. Box 9 provides an example of the use of national AMU data in this way.

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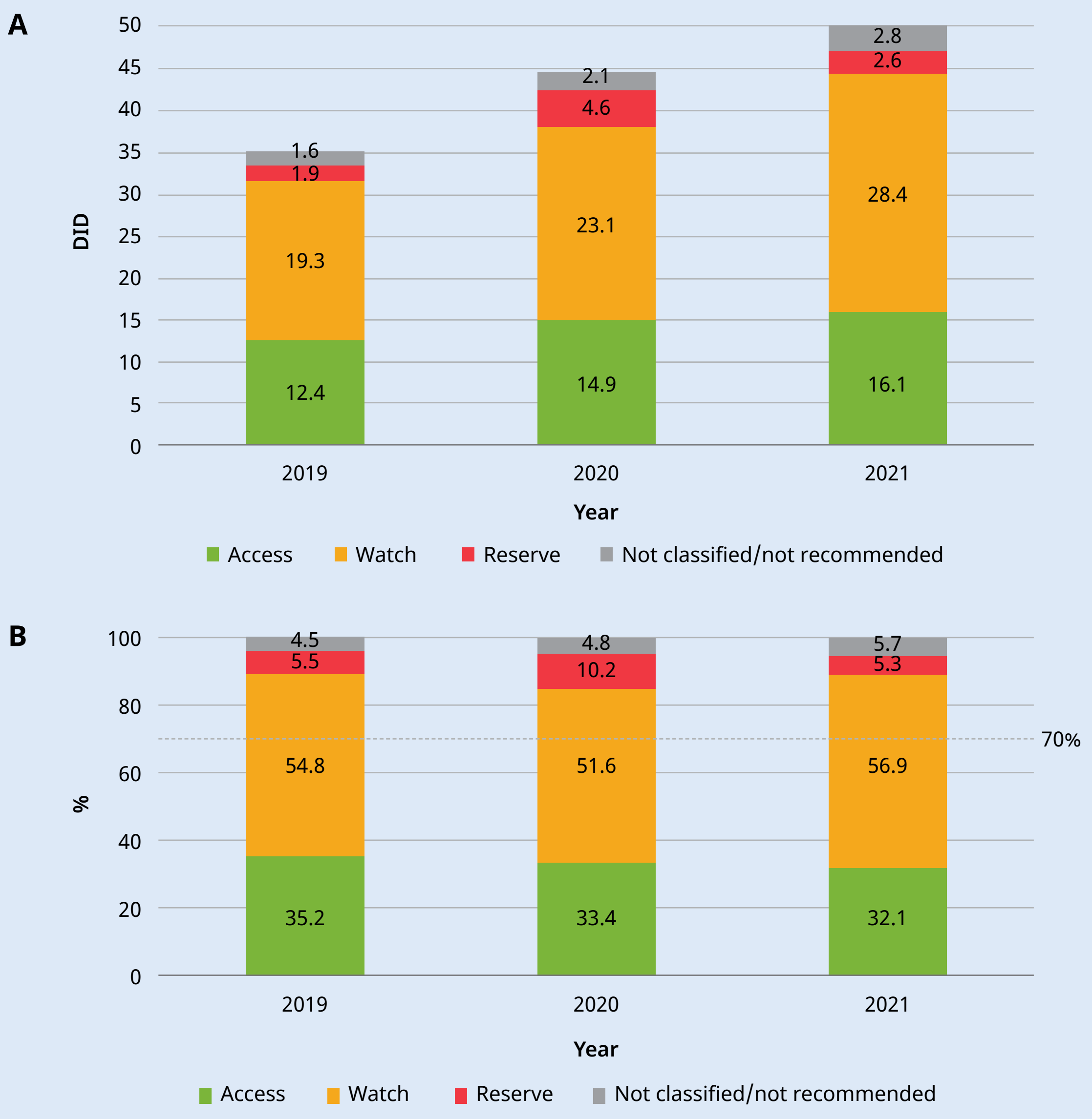
Assorted medicines at a pharmacy, health clinic, Cambodia, 2015.

Box 9. Case study on using national AMU data to track AMU goals

Case study 1: Country X established a national surveillance system in 2019 to monitor medicine-level antibiotic use. Over 3 years (2019–2021), total antibiotic use and use by AWaRe category followed the trends illustrated in Fig. 27.

Fig. 27. Antibiotic use by AWaRe category in country X (A, DID and B, %)



AMU was higher than the median of 18 DID in 64 countries that contributed to GLASS in 2021, with overuse of Watch and Reserve antibiotics and failure to attain the 70% Access target. This information generated political interest and commitment by the government of country X to reduce and optimize AMU in all sectors. In 2021, while updating and developing the national action plan on AMR 2022–2026, the ministries of health and of agriculture and forestry agreed to include a goal of reducing total national antibiotic use by 20% and increasing the proportion of Access antibiotic use to 70% by 2025. Country X made a number of policy interventions to improve antibiotic use over several years, as shown in the following intervention timeline.

Intervention	2022	2023	2024
Regulations	Ban supply of antibiotics without prescription by authorized prescribers. Support universal health coverage to enable access to antimicrobials when needed.	Reinforce ban on manufacture and supply of Not-recommended antibiotics. Restrict Reserve antibiotics to prescription only. Enforce ban on OTC dispensing of Reserve and Not recommended antibiotics.	Restrict Watch antibiotics to prescription only.
Guidelines	Develop national guidelines for antibiotic treatment in human health. Develop national AMS guidelines for human health.	Develop national guidelines for antibiotic treatment in animal health aligned with the WHO list of medically important antimicrobials. Develop measures to monitor use, and ensure compliance of the animal health sector.	
Training		Disseminate national guidelines for antibiotic treatment in human health. Train health workers at all levels in use of the national antibiotic treatment guidelines.	Disseminate national guidelines for antibiotic treatment in human health. Train animal health practitioners in use of the new guidelines.
AMS		Establish and train AMS teams in all secondary and tertiary hospitals.	Implement AMS in primary care.
Public awareness	Launch campaign on management of AMR and infection, including antibiotic use		

In 2024, during the mid-term review of the national action plan on AMR, national antibiotic use was evaluated again (Fig. 28).

Fig. 28. Antibiotic use by AWaRe category in country X (A, DID; B, %)

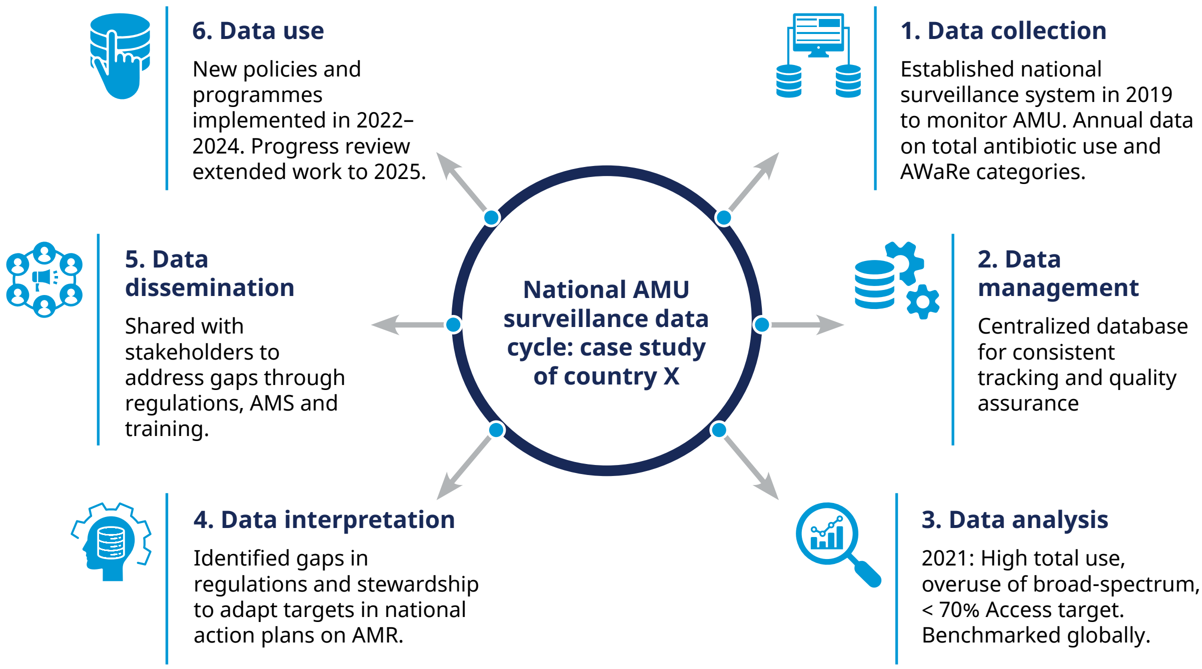
Country X achieved the goal of reducing total AMU by 20% (from 49.9 DID in 2021 to 39.9 DID in 2024); however, high use of Watch antibiotics persisted, and the proportion of Access antibiotic use was still below 70%. Furthemore, overall antibiotic use remained much higher than in other countries. With this information, country X planned post-2024 interventions to promote use of narrower-spectrum antibiotics (Table 7).

Table 7. Post-2024 interventions to promote use of narrower-spectrum antibiotics

Post-2024 interventions	Description
Regulations	Integrate AWaRe classification into medicines policies, the EML, health insurance and procurement lists. Limit distribution of parenteral third-generation cephalosporins and fluoroquinolones (overused Watch antibiotics) to secondary and tertiary health-care facilities and clinics that manage cases of gonorrhoea. Enforce restrictions in prescribing and dispensing Watch antibiotics to secondary and tertiary care. Restrict use, and monitor use of medically important antimicrobials in animals by AMU surveillance.
Guidelines	Update guidelines for human antibiotic treatment from the WHO AWaRe book.
Training	Require AWaRe training and certification of physicians as part of continuing medical education.
Country X will continue to survey national antibiotic use in 2025 and 2026 to monitor progress in achieving its goal of reducing total national antibiotic use by 20% and increasing the proportion of use of Access antibiotic use to 70% by 2026.	

A case study from country X illustrates how national AMU surveillance data can be applied in all six steps of the data cycle, from data collection to data use 3, to inform and drive policy (Fig. 29).

Fig. 29. National AMU surveillance data cycle: case study of country X



7.2.2 Strengthening regulatory, procurement and supply systems

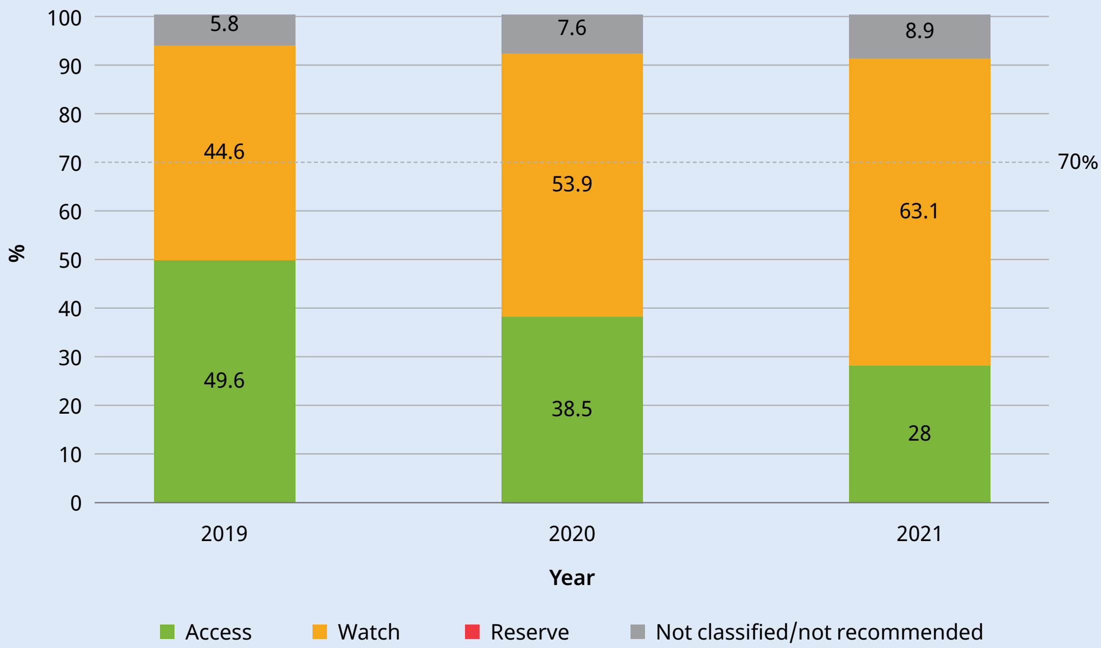
National medicine-level data on AMU can provide valuable information on the strengths and weaknesses of the pharmaceutical supply chain. By understanding the volume and rate of use, countries can more accurately forecast stock requirements, manage pharmaceutical budgets and reduce the risk of stock-outs and waste. This information can also be used in the design of appropriate procurement strategies, planning lead times and development of effective distribution mechanisms to ensure that antimicrobials are available subnationally and locally, ultimately improving access at points of care.

Table A2 in the Annex summarizes use of elements of national medicine-level data to strengthen procurement and supply systems. Box 10 provides an example of the usefulness of national medicine-level data in this way.

Box 10. Case study of use of national AMU data to strengthen procurement and supply systems

Case study 2: Trend in relative use of antibiotics according to AWaRe classification in country Y over 3 years (Fig. 30)

Fig. 30. Antibiotic use by AWaRe category as a percentage of total AMU in %



National AMR surveillance data for priority Enterobacterales from blood isolates indicated the following trends over 3 years (Fig. 31 and 32).

Fig. 31. Susceptibility of *Escherichia coli* isolates from blood

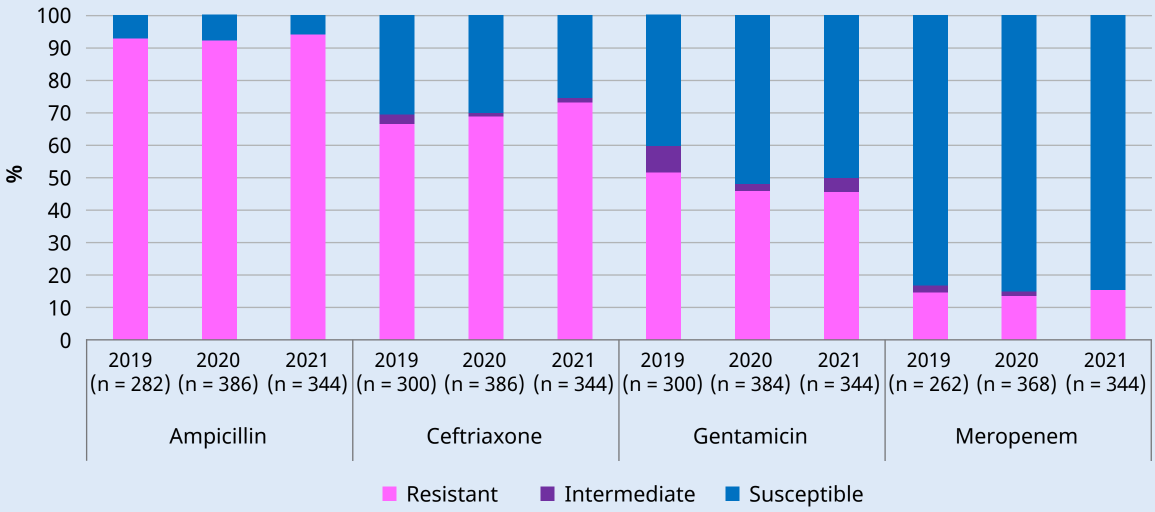
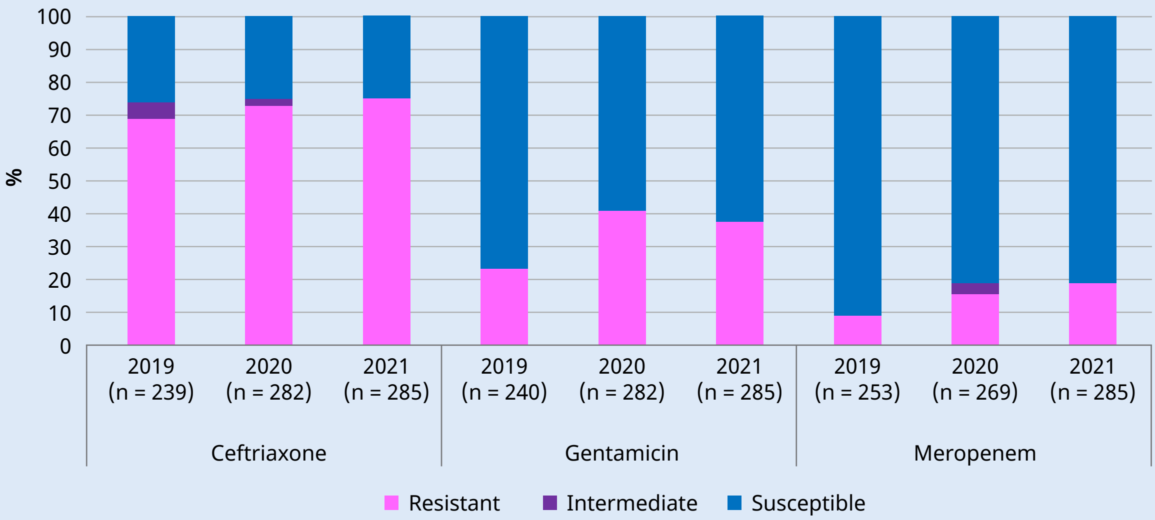


Fig. 32. Susceptibility of *Klebsiella pneumoniae* isolates from blood



Frequent carbapenem resistance without access to necessary antibiotics. Despite the high proportion of resistance of common Gram-negative organisms to carbapenems, the national medicine-level AMU surveillance system did not identify use of any Reserve antibiotics active against those organisms. Instead, there was notable use of antibiotics that are not recommended on the WHO model EML.

Past policy decisions that had not been implemented. Further investigation by the ministry of health showed that, despite addition of the Reserve antibiotic colistin to the national EML in 2020, it had not been used because there was insufficient funding to procure it. Furthermore, although the department of hospital services had intended to prepare guidance on the treatment of carbapenem-resistant Enterobacterales in tertiary hospitals, this had not yet been completed.

New decisions based on the data analysis. As a result of the findings in national medicine-level data, development of guidance on the treatment of carbapenem-resistant Enterobacterales was expedited, and the ministry of finance was requested to increase the domestic budget allocation for procurement of essential Reserve antibiotics, including colistin.

Table 7 provides a non-exhaustive list of common resistant pathogens and examples of essential antibiotics used in their treatment. In settings with a high prevalence of infections caused by such pathogens, use of these antibiotics should be reported in AMU surveillance data.

Table 7. Common resistant pathogens and examples of essential antibiotics used in their treatment

Pathogen	Infection type	Essential antibiotic[a]	AWaRe category
Burkholderia pseudomallei	Systemic	Ceftazidime Meropenem	Watch Watch
Carbapenem-resistant Enterobacterales	Systemic	Colistin (and other Reserve antibiotics)	Reserve
Extended-spectrum beta-lactamase-producing Enterobacterales	Systemic	Meropenem	Watch
Extended-spectrum beta-lactamase-producing Enterobacterales	Local (cystitis)	Nitrofurantoin	Access
Methicillin-resistant *Staphylococcus aureus*	Systemic	Vancomycin Linezolid	Watch Reserve
Vancomycin-resistant enterococci	Systemic	Linezolid	Reserve

[a] Non-exhaustive list citing only antibiotics that are on the WHO Model EML

7.2.3 Improving the consistency of a national medicines policy

National AMU data indicate the types and quantities of medicines used, which can be compared with the goals of the national medicines policy. This policy guides the availability, accessibility and appropriate use of medicines, with other documents, including the EML, prescribing guidelines and policies.

An example of the use of national AMU data in this way is provided in Box 11. Table A3 in the Annex summarizes use of elements of national AMU data in the national medicines policy.

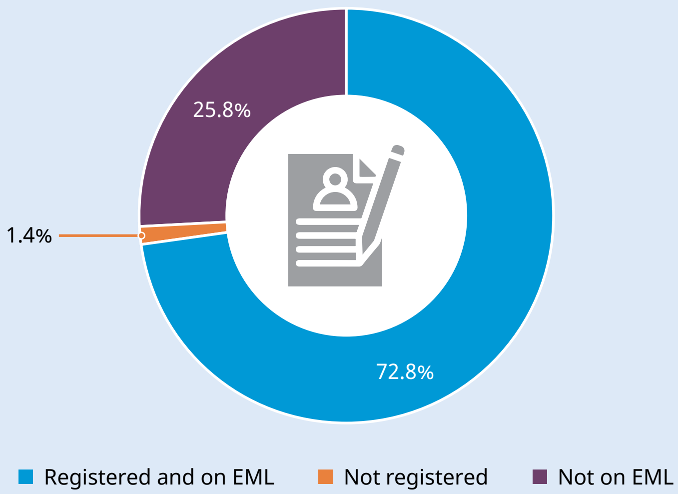
Box 11. Case study of use of national AMU data to evaluate concordance with the national medicines policy

Case study 3: Country Z established national AMU surveillance in 2018 and has been increasing the quality of the data and coverage of its surveillance system. In 2021, 229 antimicrobial products were used in the country. Of these, 217 products, selected according to WHO GLASS methodology and comprising different brands, strengths and formulations, were included in AMU surveillance, including 35 antimicrobial substances.

Three products – two manufactured locally (amoxicillin syrup 125 mg/5 mL, 60 mL-bottle, and erythromycin syrup 125 mL/5 mL, 60-mL bottle) and one imported (amoxicillin capsule 250 mg, 10 capsules) product – were not registered with the food and drug department of the ministry of health. Nevertheless, use of these unregistered products accounted for 1.4% of total DID.

Of the 217 products that were monitored, 56 (25%) were not on the national EML. Many of the non-EML products used consisted of various strengths and/or formulations of antibiotic substances that were already on the EML. Others were cefpodoxime, ceftriaxone/sulbactam, cefuroxime, dicloxacillin, lincomycin, streptomycin, tetracycline and even cefixime/*Lactobacillus acidophilus* and cefpodoxime/levofloxacin, which are classified as Not recommended in WHO AWaRe. Use of non-EML antibiotics accounted for 25.8% of the total DID. The registration and EML status of the antibiotics was summarized as shown in Fig. 33.

Fig. 33. Registration and national EML status of medicine-level use as a percentage of total use



As a result of these findings, the food and drug department implemented the following measures:

- registration of the two unregistered products that were manufactured locally, as they were in line with other registered products in the country and the national EML and were produced in response to a shortage of similar products that were usually imported;
- issuance of a notice to the importer of the amoxicillin capsule 250 mg, 10 capsule, to cease importation of the product, as the pack size did not conform to the national EML;
- addition of cefuroxime to the national EML as a treatment option for community-acquired pneumonia in patients with non-immediate hypersensitivity to penicillins; and
- development of a catalogue of antibiotic products to guide centralized national procurement to minimize use of Not recommended and non-EML antibiotics such as cefixime/*Lactobacillus acidophilus* and cefpodoxime/levofloxacin.

This example demonstrates use of routine national AMU data for assessing overall AMU for alignment with the national medicines policy and development of targeted policy interventions to ensure optimal AMU.

7.2.4 Contributing to WHO evidence bases with AMU data

While national AMU data are used primarily to identify areas for improvement and to develop and monitor strategies to optimize AMU in a country, they can also be used to strengthen the supranational geographical evidence base (e.g. WHO regional and global levels), including monitoring of patterns of trends in both AMU and AMR. For example, the Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS) and GLASS-AMU surveillance enable comparisons among countries in the Western Pacific and globally for potential benchmarking, identifying the drivers of AMR and international AMR policy (*6*,*30*).

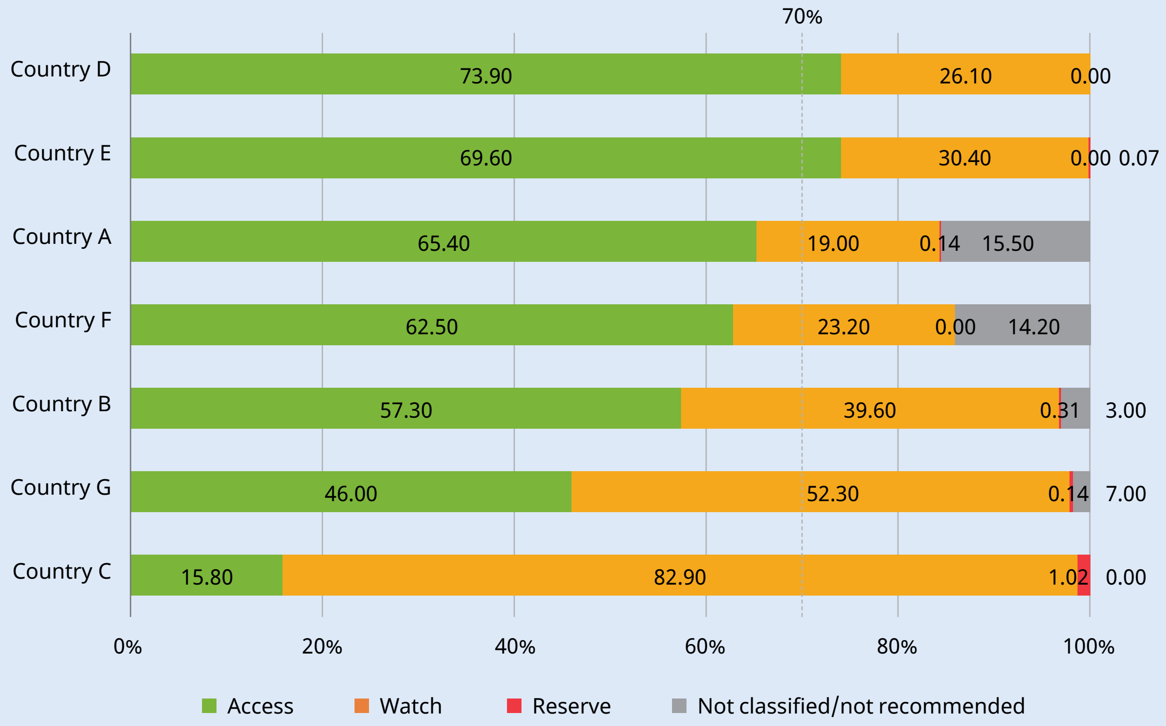
Table A4 in the Annex summarizes the contribution of key elements of national medicine-level data to supranational bases on AMU.

An example of use in this way of national medicine-level data is provided in Box 12.

Box 12. Case study on the utility of national medicine-level data to contribute to regional and global evidence based on AMU

Case study 4: A supranational regional surveillance system was launched as a regional platform to help countries understand their patterns of AMU and guide policies and stewardship. National AMU data was reported in 2023 for seven countries in the region (A–G in Fig. 34).

Fig. 34. National use of AWaRe antibiotics by country, 2023



This report provides a baseline for national AMU in these countries. Countries D and E met the target of at least 70% of total use being of Access antibiotics. The large proportions of Watch antibiotics used in other countries merits further study and provides opportunities for AMS. Use of Reserve antibiotics was limited, comprising ≤ 0.2% of AMU in most countries, indicating potential problems of access.

In view of limitations in the selection of data sources and in data coverage and the different contexts and profiles of AMU in each country, comparisons should be made carefully with consideration of potential differences. The data can be used for orientation and for prioritizing further investigations and interventions.

The small proportion of use of Access antibiotics in some countries could indicate inappropriate use. These countries should investigate the availability of the medicines market and current treatment guidelines to understand the patterns of and reasons for the results.

The limited use of Reserve antibiotics could indicate problems of access, even when they are required in specific critical situations. The countries could investigate whether Reserve antibiotics are available on their markets and, if they are, why the surveillance system did not record their use.

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8 Placing medicine-level AMU data in a broader context

Khanh Vinh District Hospital, Viet Nam, 2015.

8.1 Limitations of medicine-level AMU data

Medicine-level data on AMU provide valuable information on the types and quantities of medicines used in a country or facility. The data provide critical information about the volume and pattern of AMU, forming a basis for decisions on medicine registration, selection, procurement, distribution, prescribing, dispensing and use. They support both optimization and stewardship of the supply chain, targeted interventions, regulatory oversight and better access at points of care.

Even with optimal disaggregation, however, data on medicine-level AMU may still lack the clinical information necessary to understand how and why antimicrobials are used. Clinical data on AMU that provide qualitative information on use of antimicrobials can provide this type of information. In some cases, when medicine-level data are not readily available, for example if the team is still establishing medicine-level surveillance, surveys can be performed of clinical use. Medicine-level and clinical data provide a comprehensive evidence base for recommendations to improve AMU.

8.2 Added value of clinical data

Clinical data provide information on specific elements of the use of antimicrobials, including the people involved, treatment details and context, depending on the types of variables collected.

- For stakeholders, clinical data provide information on the patient taking the antimicrobial, the prescriber and/or the dispenser.
- Clinical data provide information on the antimicrobial regimen, the indication for treatment and relevant diagnostic details.
- Clinical data can provide additional information for the objective of surveillance. With respect to access, data can be collected on where the medicines were purchased and whether the full course of treatment was purchased and administered. For the purposes of stewardship, clinical data provide information on adherence to guidelines, treatment reviews or a change from parenteral to oral administration.

8.3 Sources of clinical data

In clinical surveillances, data are retrieved mainly from medical records, prescription forms and insurance claims. The usefulness of clinical data depends, however, on their availability and the detail and quality, which depend in turn on the accuracy of record-keeping systems. When recorded data are not available or are of poor quality, clinical data can be collected for prospective or qualitative and/or quantitative studies, including research on drug use and in point prevalence surveys or audits. Studies may be cross-sectional or long-term and on a small scale (such as a specific ward) according to the findings on medicine use. Studies may be repeated after an intervention in a quasi-experimental study to evaluate the impact of the intervention. More information on PPS methodology is available through the WHO PPS protocol and the Global-PPS initiative, which includes tools for harmonized data collection and benchmarking in different health-care settings (*10*,*31*).

8.4 Drawbacks of clinical data

Collection of clinical data is limited because of the time required to extract information and the associated cost. Data-sharing, data privacy, confidentiality and ethical and legal issues may be obstacles. Clinical data are limited in terms of their representativeness, and their precision is limited by sample design and sizes.

The main metric used in clinical surveillance is the observed prevalence or proportion of use of antimicrobials in the population surveyed. The metric could also be the prevalence of an event, such as the proportion of prescriptions for at least one antibiotic in the number of prescriptions surveyed. The choice of metric depends on the objectives of the survey or audit.

9 Conclusion

Pharmacy in Estonia, 2019.

With respect to the role of surveillance of AMU, it is important to remember that it is not an end in itself. Rather, surveillance data are a foundation for action, regulations, policies and stewardship interventions to improve AMU. To ensure that data result in meaningful change, stakeholders must be identified and actively engaged throughout, from planning and data collection to interpretation and implementation.

While individual data sources and metrics offer valuable insights, they rarely tell the whole story. Comprehensive understanding requires use of all the available national data and various metrics to capture the complexity of AMU.

This guide is a step in translation of data into action. Further WHO guidance in partnership with countries will follow.

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Health Workforce in Kisumu, Kenya -2024.

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Annex

Nurses engaged in data collection in hospital, Viet Nam, 2015.

Utility of national medicine-level data

Table A1. Utility of national medicine-level data for making and monitoring progress in meeting national goals to optimize AMU

Intervention: Monitor progress toward national goals to optimize antimicrobial use

Medicine-level data indicators

To be measured with disaggregation by level of health care, if possible:

- **National level:**
  - total use in DID;
  - relative use by AWaRe classification (including those classified as Not recommended), in DID and %;
  - relative use by pharmacological subgroup, in DID and %;
  - relative use by route of administration, in DID and %;
  - antimicrobial substances comprising 75% of total use (DU75);
  - differences in patterns of use by region or sub-region and by quarter (to account for seasonality), if available.
- **Primary care (with oral formulations as proxy):**
  - estimated total use in DID;
  - estimated relative use by AWaRe classification, in DID and %;
  - estimated relative use by pharmacological subgroup, in DID and %.
- **Hospital level (with parenteral formulations as proxy):**
  - estimated total use, in DID;
  - estimated relative use by AWaRe classification, in DID and %;
  - estimated relative use by pharmacological subgroup, in DID and %.

Additional data types and analyses

- data on demography, burden of infectious diseases;
- data on availability of antimicrobials, including stock-outs and shortages;
- context: medicines regulations, policies and systems.

Common data biases and errors

- Data completeness, representativeness, internal quality and comparability

Stakeholders involved in collecting and collating data

- national stakeholders involved in import, manufacture and distribution of antimicrobials;
- medicines regulatory authorities; and
- coordinating body for surveillance of national AMU.

Target audience of outputs

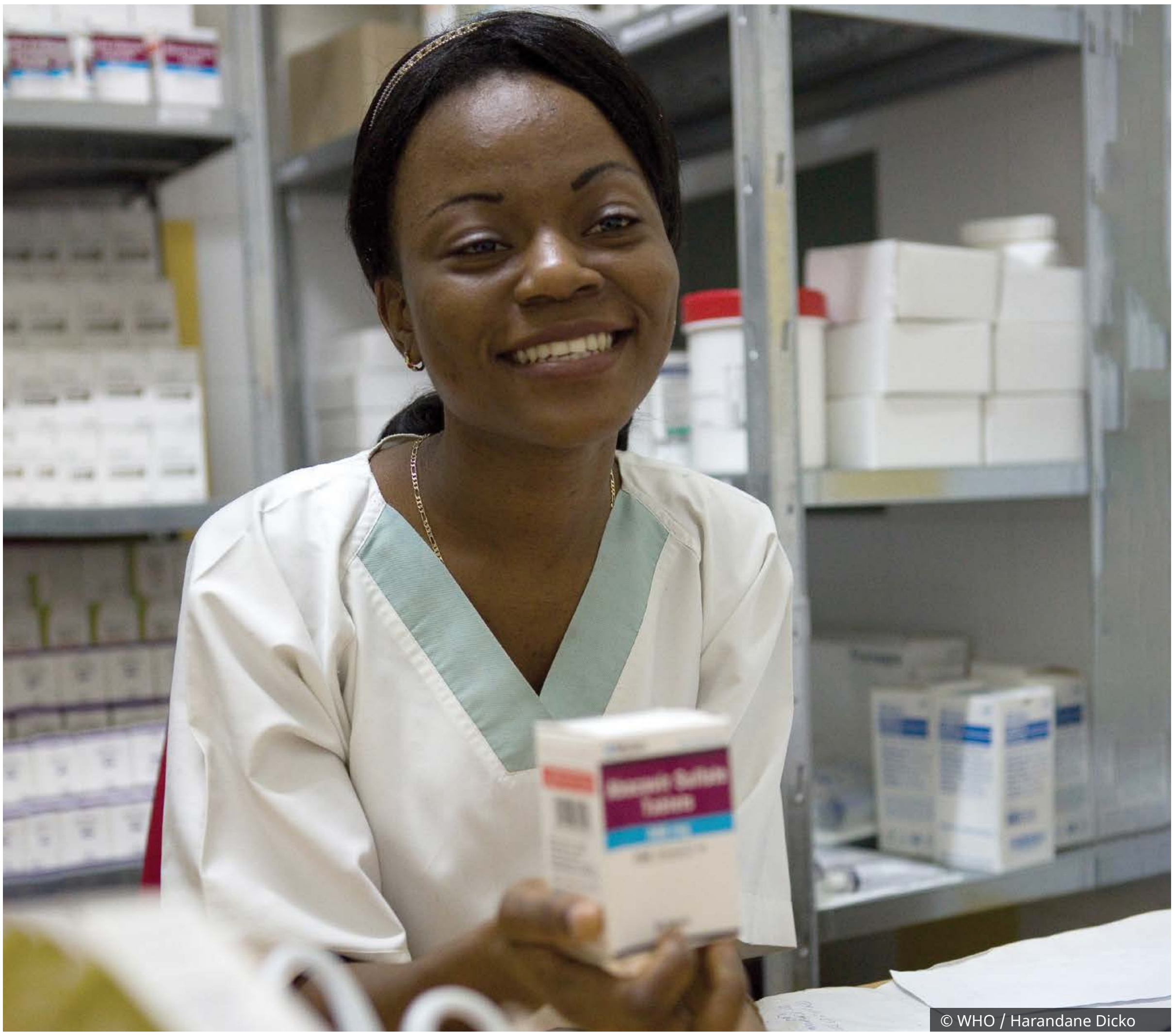
- ministries of health;
- national AMR committees;
- national body for appropriate use of medicines;
- national body for health-care facility accreditation and/or patient safety and quality of care;
- professional health societies;
- health-care facilities.

Presentation and reporting of data

- national summary report, with data visuals, analysis and interpretation;
- regular dissemination of data (ideally every year, at least every 2 years), potentially on dashboards

Action

- Formulate specific, measurable, achievable, realistic, time-bound goals to reduce unnecessary use and/or increase relative use of Access antibiotics.



HIV/AIDS prevention, treatment and care, Democratic Republic of the Congo, 2013.

Table A2. Utility of national medicine-level data on AMU to evaluate and strengthen national procurement and supply systems

Intervention: Evaluate and strengthen national procurement and supply

Medicine-level data indicators

- **National medicine-level data**
  - total use in DID;
  - relative use by AWaRe classification (including those classified as Not recommended), in DID and %;
  - relative use by pharmacological subgroup, in DID and %;
  - relative use by route of administration, in DID and %;
  - DU75.

Additional data types and analyses

- data on demography, burden of infectious diseases;
- data on availability of antimicrobials, including stock-outs and shortages;
- data on AMR of key pathogens (with reference to GLASS-AMR);
- price of antibiotics;
- national EML, treatment guidelines.

Common data biases and errors

- Data completeness, representativeness, internal quality and comparability

Stakeholders involved in collecting/collating data

- national stakeholders in import, manufacture and distribution of antimicrobials;
- medicines regulatory authorities;
- national AMU surveillance coordinating bodies.

Target audience of outputs

- ministries of health;
- national and subnational medicines procurement teams;
- national AMR committee;
- medicines regulatory authorities;
- health-care facilities.

Presentation and reporting of data

- national summary report with data visuals, analysis and interpretation;
- regular dissemination of data (ideally every year, at least every 2 years), potentially on dashboards.

Actions

- Identify essential antimicrobials with unusually high or low use (as compared with other relevant countries, previous years, guideline recommendations), which may indicate problems of access (due, e.g. to stock-outs or inefficient distribution), oversupply or wastage, and investigate possible stages in the life cycle of medicines to address the issue.
- Identify "Not recommended" antibiotics in circulation, and restrict their use and supply.

Table A3. Utility of national medicine-level data on AMU to evaluate concordance with the national medicines policy

Intervention: Evaluate concordance with the national medicines policy

Medicine-level data indicators

To be measured with disaggregation by health level, if possible:

- **National medicine-level data:**
  - total use in DID;
  - relative use by AWaRe classification, including those classified as "Not recommended", in DID and %;
  - relative use by pharmacological subgroup, in DID and %;
  - relative use by route of administration, in DID and %;
  - DU75;
  - relative use of antibiotics not on the national EML;
  - relative use of antibiotics not in antibiotic prescribing guidelines.
- **primary care (with oral formulations as a proxy):**
  - estimated total use, in DID;
  - estimated patterns of use by AWaRe classification, in DID and %;
  - estimated relative use by pharmacological subgroup, in DID.
- **hospital level (with parenteral formulations as a proxy):**
  - estimated total use, in DID;
  - estimated patterns of use by AWaRe classification, in DID and %;
  - estimated relative use by pharmacological subgroup, in DID and %.

Additional data types and analyses

- data on demography and burden of infectious diseases;
- data on availability of antimicrobials, including stock-outs and shortages;
- data on AMR and susceptibility;
- **national antibiotic registration data:**
  - list of all registered antimicrobials and formulations;
  - proportion of registered antibiotics on the national EML;
  - concordance of the national EML with the WHO model list;
  - proportion of registered antibiotics in the Not recommended category of the AWaRe classification
  - List of antimicrobials covered by health insurance
- **Alignment of policies:**
  - Proportion of antibiotics recommended in the antibiotic prescribing guidelines on the national EML
  - Integration of the AWaRe classification and AMS principles into national EML and antibiotic prescribing guidelines
- **Access:**
  - Proportion of local health facilities with a core set of affordable Access/Watch antibiotics included in the antibiotic prescribing guideline
  - Proportion of a core set of available Access/Watch antibiotics included in the antibiotic prescribing guideline

Common data biases and errors

- Data completeness, representativeness, internal quality and comparability

Stakeholders involved in collecting/collating data

- national-level stakeholders involved in import, manufacturing and distribution of antimicrobials;
- medicines regulatory authorities;
- coordinating bodies for national medicine-level surveillance.

Target audience of outputs

- ministries of health,
- national AMR committee,
- national AMS technical working group,
- medicines regulatory authorities,
- health-care facilities.

Presentation and reporting of data

- national summary report with data visuals, analysis and interpretation;
- regular dissemination (ideally every year, at least every 2 years), potentially on dashboards.

Action

- Compare national medicine-level data on AMU with the national EML to identify types and quantities of non-essential antimicrobials used in the country.
- Compare proxy measures of use in primary care and in hospitals (e.g. % of oral and parenteral use, respectively) with recommendations in regulations and antimicrobial prescribing guidelines to identify signals of inappropriate use in each setting, which could be further investigated in audits or surveys to collect clinical data.
- Resolve any discrepancies between medicines policies by ensuring that antimicrobials recommended for use in the country are registered, on the national EML and in antimicrobial prescribing guidelines.
- Develop strategies to improve compliance with national medicines policies, including increasing relative use of recommended antibiotics.

Khanh Vinh District Hospital, Viet Nam, 2015.

Table A4. Utility of national medicine-level data to contribute to regional and global evidence bases on antimicrobial use

Intervention: To contribute evidence bases on the WHO regional and global level on antimicrobial use

Medicine-level data indicators

The following indicators may be measured nationally, with disaggregation by health level (i.e. primary care, hospitals) if possible:

- total use, in DID;
- relative use by AWaRe classification, including Not recommended antibiotics, in DID and %;
- relative use by pharmacological subgroup, in DID and %;
- relative use by route of administration, in DID and %;
- DU75.

Additional data types and analyses

- data on demography, burden of infectious diseases; and
- data on availability of antimicrobials, including stock-outs and shortages.

Common data biases and errors

- Data completeness, representativeness, internal quality and comparability

Stakeholders involved in collecting/collating data

- national stakeholders involved in import, manufacture and distribution of antimicrobials;
- medicines regulatory authorities;
- coordinating bodies for national medicine-level surveillance on AMU.

Target audience of outputs

- national governments;
- G7, G20, ASEAN, BRICS
- national and international policy-makers;
- donors.

Presentation and reporting of data

- national summary report with data visuals, analysis and interpretation by region and country;
- regular data dissemination (ideally every year, at least every 2 years), potentially on dashboards.

Actions

- Enrol and share national medicine-level data on AMU with supranational regional (where available) and global medicine-level surveillance systems.
- Distribute data among stakeholders;
- Use data to develop and implement policies to improve AMU.

World Health Organization
20 Avenue Appia1211
Geneva 27
Switzerland
https://www.who.int/health-topics/antimicrobial-resistance