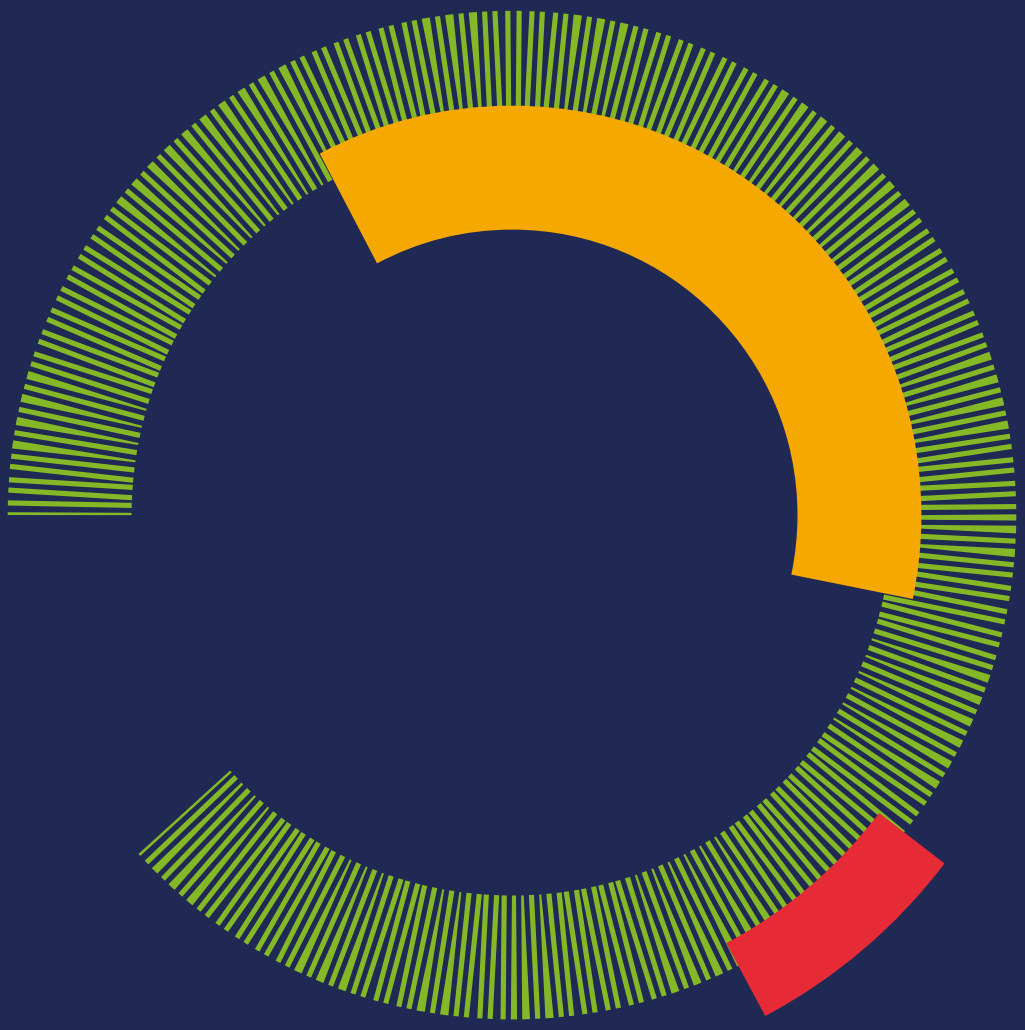
Global Antimicrobial Resistance and Use Surveillance System (GLASS) report

Antibiotic use data for 2022



World Health Organization

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Foreword

Antimicrobial resistance (AMR) is a critical global health threat that undermines the safety of routine medical procedures and reverses many advances in modern medicine by rendering antimicrobials ineffective against infections. Inappropriate use of antimicrobials is a major driver of AMR; at the same time, inadequate access to essential, quality-assured medicines remains a problem in many resource-limited settings.

National and global surveillance data on antimicrobial use (AMU) guide stewardship and monitoring of progress towards better access to and use of antibiotics. To accelerate this work, global leaders approved a political declaration at the 79th United Nations General Assembly High-level Meeting on AMR, which committed them to a clear set of targets and actions. These include ensuring that 70% of antibiotics used globally are in the WHO AWaRe (Access, Watch, Reserve) Access group and building national surveillance systems to report high-quality data on AMU to the Global Antimicrobial Resistance and Use Surveillance System (GLASS) by 2030.

This report describes progress in the participation of countries, territories and areas (CTAs) in GLASS-AMU by the end of 2023. Since the launch of the national AMU surveillance component of GLASS in 2020, participation has increased; 90 countries and territories were enrolled by the end of 2023, and 74 report national data over the years. The report also shows, however, that global participation remains below 50%, with important gaps due to non-participation of non-European and lower-income countries. WHO is committed to continuing to consolidating and extending GLASS in the coming years with support from Member States, WHO regional and country offices, regional networks, WHO collaborating centres and other international partners.

This GLASS report, produced in collaboration with Member States, summarizes estimates of AMU in 2022 and interpretation of the data according to the WHO AWaRe framework, the system developed by WHO to guide preparation of national and institutional lists of essential medicines and treatment guidelines, to meet priority health-care needs while optimizing antibiotic use for common infections.

Analysis of the data demonstrates considerable variation in antibiotic use by region and income level, indicating both areas of concern and opportunities for improvement. Disproportionate use of Watch antibiotics and underutilization of recommended Access first-line treatments indicates that targeted antibiotic stewardship is required. Better data analysis, interpretation and use and additional national targets for antibiotic use according to population health requirements are among WHO's priorities for the near future. The WHO AWaRe antibiotic book will be useful by providing a template for developing or adapting national antibiotic guidance for prescribers.

With ongoing support from WHO and international partners, countries can strengthen their AMU surveillance systems and use the evidence generated to effectively improve the quality of patient care and combat AMR.

Dr Yukiko Nakatani

Assistant Director-General a.i.

WHO Antimicrobial Resistance

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Leadership, coordination and main technical contributions

Development of the report was coordinated by Martina Escher, who was also the lead author, and supervised by Benedikt Huttner, Head, Control and Response Strategies unit in the Department of Surveillance, Prevention and Control in the WHO AMR Division, under the guidance of Department Director, Yvan Hutin. Significant technical contributions to data collection, analysis, interpretation and review were made by unit staff members Verica Ivanovska, Arno Muller, Daire O'Doerthy and Deborah Tong.

Collection and compilation of data for the report

WHO acknowledges the invaluable contributions of the national focal points and their alternates in the CTAs, who prepared and reported their data on AMU to GLASS. They are listed below alphabetically by CTA.

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Review group

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Abbreviations

AMC	antimicrobial consumption
AMR	antimicrobial (or antibiotic) resistance
AMU	antimicrobial (or antibiotic) use
ATC	Anatomical Therapeutic Chemical System
AWaRe	Access, Watch, Reserve
CTA	country, territory or area
DDD	defined daily dose
DID	defined daily dose per 1000 inhabitants per day
GLASS	Global Antimicrobial Resistance and Use Surveillance System
GPW	General Programme of Work
GPW 2023 60% Access target	WHOs 13th General Programme of Work goal of at least 60% of human antibiotic use in a country to be Access antibiotics by 2023
IQR	interquartile range
LMIC	low- and middle-income countries
m-AMU	medicine-level antimicrobial (or antibiotic) use
UN	United Nations
UNGA 2030 70% Access target	United Nation General Assembly political declaration in 2024 target of ensuring that at least 70% of antibiotics used globally are in the WHO AWaRe Access group
WHO	World Health Organization
WHO EML	WHO Model List of Essential Medicines

Glossary

Antimicrobial (or antibiotic) medicine-level use (m-AMU). Also known as "antimicrobial consumption" (AMC), m-AMU estimates the quantity of AMU aggregated at the level of medicines. The quantity is usually expressed as the defined daily dose (DDD) in kilograms. Data on m-AMU are collected by routine surveillance and quantify the volume of antimicrobial products procured, distributed, prescribed, dispensed or reimbursed over a certain period to a national, subnational or hospital population. National m-AMU data are collected and reported globally to WHO GLASS.

AWaRe classification. The WHO AWaRe (Access, Watch, Reserve) classification is used in local, national and global antibiotic stewardship. Antibiotics are classified into three groups, Access, Watch and Reserve, according to their impact on AMR to signal the importance of their appropriate use. The AWaRe classification was first published in 2017 and is updated every 2 years, with the WHO Model List of Essential Medicines (EML).

National target for use of AWaRe Access antibiotics. The target is used to monitor the quality of national antibiotic use according to the AWaRe classification from national data. As most infections are mild, they can be effectively treated with Access group antibiotics, such as amoxicillin and amoxicillin–clavulanate, which are narrow-spectrum, low-cost and safe and have little potential for development of resistance. The initial Access target was established in WHO's 13th General Programme of Work, which set the goal of at least 60% of human antibiotic use in a country to be Access antibiotics by 2023 (GPW 2023 60% Access target). Recognizing that inappropriate use of antibiotics is a key driver of resistance, Member States endorsed the target in November 2022 at the Third Global High-level Ministerial Conference on AMR in Muscat, Oman. They subsequently committed themselves to a more ambitious target at the 2024 United Nations (UN) General Assembly High-level Meeting on AMR: by 2030, at least 70% of global human antibiotic use should be with WHO Access antibiotics (UNGA 2030 70% Access target).

WHO EML. A list published by WHO of medicines considered to be essential for addressing the priority health requirements of populations. The list is updated every 2 years

1. Introduction

1.1 Monitoring of antimicrobial use (AMU)

AMR is a critical global health threat that undermines the safety of routine medical procedures and reverses many advancements in modern medicine by making antimicrobials ineffective to treat infections. Recent estimates identify AMR as a leading cause of death worldwide, with the highest mortality rates in low-resource settings *(1)*.

Inappropriate use of antimicrobials is a major driver of AMR. At the same time, inadequate access to essential, quality-assured medicines remains a problem in many resource-limited settings. Over the past two decades, global AMU by humans has increased, particularly in low- and middle-income countries (LMIC), with a shift towards broad-spectrum Watch antibiotics in the WHO AWaRe classification *(2–4)*. The trend is partly a result of improved access to medicines resulting from economic development in some parts of the world; however, it also indicates a problem of inappropriate use of antibiotics, such as for self-limiting viral respiratory tract infections.

In 2015, at its sixty-eighth session, the World Health Assembly adopted a global action plan on antimicrobial resistance *(5)* to ensure the continuity of successful treatment and prevention of infectious diseases with effective, safe medicines. The plan calls for optimizing AMU in the human, animal and agricultural sectors and strengthening surveillance and research to better understand AMU globally.

To address the lack of actionable data on AMU in human in many LMIC, WHO launched the global programme on surveillance of AMU in 2016 *(6)*. The programme provides global standards, methods and tools to help countries develop national surveillance systems that can provide high-quality data on AMU in the human sector. The data can be used for benchmarking and monitoring progress towards more appropriate use of antibiotics. After the pilot phase *(6)*, surveillance of AMU was included in GLASS in 2020 *(7)*. The first annual call for data for GLASS-AMU was made in 2021 *(8)*. Countries are invited to report data every year, to be published on the GLASS dashboard *(9)*.

The GLASS-AMU methodology relies on data on AMU at the medicine levels (m-AMU) as a proxy for AMU by humans *(10)*. Monitoring of AMU complements surveillance of AMR and provides a basis for policies, regulations and interventions to optimize AMU and strengthen pharmaceutical systems. Moreover, establishment of AMU monitoring systems may prompt reviews of the pharmaceutical market, selection, procurement and supply of medicines, health information systems and universal health coverage as part of overall health systems strengthening.

GLASS-AMU has been used to monitor progress towards achieving the AWaRe based GPW 2023 60% Access target *(11)*. The AWaRe classification was introduced by WHO in 2017 during updating of the WHO Model List of Essential Medicines and the WHO Model List of Essential Medicines for Children (WHO EML) to optimize antibiotic choices for common infections according to the spectrum of activity and potential to contribute to the emergence and spread of resistance to different antibiotics *(12)*. The WHO AWaRe framework was complemented in 2022 by the AWaRe antibiotic book, which provides specific guidance on the empirical use of antibiotics in the WHO EML *(13)*.

Despite progress, disparities in surveillance capacity, incomplete data and inadequate use of data for action limit a comprehensive response to AMR. The Seventy-sixth World Health Assembly in 2024 therefore adopted a human sector-specific WHO strategic and operational framework to address drug-resistant bacterial infections for the period 2025–2035, encouraging countries to integrate people-centred approaches and a core package of interventions *(14)*, such as strengthening surveillance of AMU and incorporating it in health sector planning and financing *(15)*. In the 2024 UN General Assembly political declaration, Member States further committed themselves to targets and actions, including reducing the number of deaths associated with AMR by 10% by 2030 from the 2019 baseline and ensuring that at least 70% of antibiotics used globally are in the WHO AWaRe Access group (UNGA 2030 70% Access target) *(16)*. Furthermore, all Member States are expected to build national surveillance systems and report data of good quality from national surveillance of AMU to GLASS by 2030 *(16)*.

The first WHO report on AMU was published in 2018, which provided an overview of WHO activities during the 2016–2018 pilot phase and summarized data on AMU in 2015–2016 from 65 CTAs *(6)*. After inclusion of AMU surveillance into GLASS in 2020, data from 26 CTAs that were formally enrolled at that time were presented in the GLASS report published in 2022 *(8)*.

This GLASS report describes global progress in GLASS-AMU surveillance and antibiotic use in 2022, reported by 60 countries. This report supplements the 2016–2022 GLASS-AMU data on the GLASS dashboard.

1.2 What's new?

New terminology. In this third WHO Global Report on AMU, new nomenclature is introduced to increase clarity and consistency in surveillance. Previously, WHO distinguished between AMC (estimates from aggregated data) and AMU (data retrieved from patient charts linking antibiotic use to indications and patient characteristics, providing detailed information on how antimicrobials are used to treat patients). As both types of data provide quantitative and qualitative information on antibiotic use, WHO now uses "antimicrobial use" for all relevant AMU monitoring data and "medicine-level" AMU data (m-AMU) when the estimates are of the volume of medicines used without additional context (previously referred to as AMC). Consequently, GLASS-AMU is used instead of GLASS-AMC to refer to GLASS surveillance of national m-AMU, and the GLASS-m-AMU method replaces the GLASS-AMC method published in 2020. A detailed rationale for this change in terminology is provided in Annex 1.

Revised inclusion criteria for systemic antibiotics. As in previous reports, the data apply to antibiotics in the Anatomical Therapeutic Chemical (ATC) classes J01 (antibacterials for systemic use), A07AA (intestinal anti-infectives) and P01AB (nitroimidazole derivatives), with a few exceptions introduced in this report. Methenamine (J01XX05) is excluded from the J01 group, as it is considered a urinary tract antiseptic rather than an antibiotic. Similarly, nystatin (A07AA02), natamycin (A07AA03) and amphotericin B (A07AA07) in the A07AA group are now categorized as antifungals and analysed with antimycotics and antifungals for systemic use (J02, D01B).

Enhanced data analysis and interpretation. The report provides an enhanced interpretation of the AMU data than in previous reports, as it is based on the WHO AWaRe framework, comprising the WHO-EML, the WHO AWaRe classification *(17)* and the AWaRe antibiotic book *(13)*. This framework guides the development of national and institutional EMLs and treatment guidelines to meet priority health-care needs while optimizing AMU for common infections.

The GLASS dashboard. The GLASS dashboard (https://worldhealthorg.shinyapps.io/glass-dashboard) is an interactive platform that presents findings from GLASS AMR and AMU at both global and CTA levels. The most recent update, in September 2024, includes all AMU data for 2016–2022 reported by CTAs by the end of the 2023 data call. Since its inception, the GLASS dashboard has undergone important improvements. The global GLASS-AMU section has been restructured, with more interactive plots and enhanced filters, allowing users to visualize data by World Bank income group classification, WHO region and other criteria. Additionally, users can now track trends over 2016–2022 and download comprehensive datasets, including detailed information on data reported and aggregated at the ATC4 level (Chemical, Pharmacological or Therapeutic subgroup), expressed in DDD and defined daily dose per 1000 inhabitants per day (DID). Users can also download extracts in PDF for individual CTAs.

1.3 Key findings and messages

- Participation in GLASS-AMU has grown steadily, with 90 CTAs (42% of 216 globally) enrolled by the end of 2023. Of these, 74 CTAs (82%) reported national m-AMU data at least once in the 2021–2023 data calls, and 67 (74%) met WHO's data quality standards for publication, including 60 for 2022 AMU data.
- Participation in GLASS-AMU is still, however, skewed towards high-income and European countries. The lack of data from large parts of the world highlights the need for continued political commitment and financial, technical and human resources support to scale up national surveillance of AMU, especially in LMIC.
- Median total AMU in 60 CTAs in 2022 was 18.3 DID, with a variation in use of over 10 times (6.3–67.7 DID) among regions and income levels, indicating both areas of concern and opportunities for improvement. Overall antibiotic use was higher in middle-income CTAs and in the South-East Asian and Eastern Mediterranean WHO regions. The causes of the observed variation are not completely understood, and better assessment of data quality and a more detailed exploration of the drivers of AMU are necessary as a basis for targeted interventions.
- As expected, oral antibiotic formulations accounted for most of the AMU use in 2022, with a median of 95% of national use. Oral administration is generally regarded as the most effective, safe, affordable method of antimicrobial administration, and its measurement can serve as a surrogate for community use.
- GLASS-AMU data for 2022 also show relatively large use of Watch antibiotics. Only 58% (35/60) CTAs reached the GPW 2023 60% Access target, and fewer, 31.7% (19/60), reached the UNGA 2030 70% Access target. Watch antibiotics contribute disproportionately to AMR, and avoidance of their unnecessary use when Access antibiotics would suffice must continue.
- Some LMICs reported very little or no use of Reserve antibiotics, indicating that access to essential Reserve antibiotics for treating infections due to multidrug-resistant pathogens should be improved. A few other CTAs reported overuse of Not classified or Not recommended antibiotics, which are combinations of several broad-spectrum antibiotics the use of which is not based on evidence or recommended in high-quality international guidelines; their use should be minimized.
- National m-AMU data allows to identify areas for intervention. Better data analysis, interpretation and use and additional national targets for antibiotic use according to population health needs are among WHO priorities for the near future. The WHO AWaRe antibiotic book will support such work by providing a template for national antibiotic guidance for prescribers.

2. GLASS AMU

2.1 Methodological framework

GLASS-AMU collects national data on m-AMU collected annually from various sources along the life cycle of medicines, serving as a proxy for actual AMU by humans. The GLASS-AMU methodology for national m-AMU surveillance is based on the ATC system for classifying antimicrobials and the DDD for expressing volume *(10)*. The ATC/DDD system, the WHO reference for monitoring and research on drug use since 1981, is updated annually *(18)*. It is also used to classify medicines on the WHO EML and in the AWaRe system.

The aim of GLASS-AMU is to collect annual data on use from all health-care sectors (private and public) at all levels (community and hospital). CTAs can provide either aggregated or disaggregated data, with a preference for disaggregated data, which allow for more nuanced analysis and targeted stewardship interventions. Countries can retrieve data from various points in the medicine lifecycle for reporting to GLASS-AMU, such as import and production records, data on distribution from central medical stores and wholesalers, dispensing and prescription records, health insurance schemes and market research companies.

CTAs are asked to report data on m-AMU of antibiotics used systemically (J01, P01AB and specific substances in A07AA [*see section 1.2*]) and are also invited to report m-AMU for antifungals (J02, D01B and specific substances in A07AA), antivirals (J05), tuberculosis drugs (J04A) and antimalarials (P01B).

2.2 CTA participation and reporting framework

Participating in GLASS-AMU (Box 1) is the first step for CTAs to commit to contributing AMU data to WHO. Every year, GLASS makes a call for data in which CTAs enrolled in GLASS-AMU are invited to report their national AMU data. In 2023, countries were invited to report annual data for 2022 and/or retrospective data to 2016, when available. CTAs can also amend previously submitted data. Data from the European Surveillance of Antimicrobial Consumption Network *(19)*, the Antimicrobial Medicines Consumption Network of the WHO Regional Office for Europe *(20)* and the Western Pacific Regional Antimicrobial Consumption Surveillance System *(21)* are shared among networks.

Box 1: Participation in GLASS-AMU

CTAs can enroll in GLASS-AMU at any stage of development of their surveillance system and can start reporting AMU data later. They can register in GLASS directly, by official communication with GLASS through WHO country and regional offices, or through regional networks. Enrolling in GLASS-AMU provides CTAs with access to WHO's technical tools and coordinated support to strengthen their national m-AMU surveillance capacity and translate data into concrete actions to improve access to and use of antimicrobials.

As part of data submission, CTAs are asked to report AMU data and to complete a questionnaire to provide information essential for assessing and monitoring data quality and guiding data analysis and interpretation. The information includes the type of m-AMU data reported, the overall estimated coverage of the volume of use reported, any systematic exclusion of antimicrobials and the population to which the data pertain, to be used as the denominator *(10)*. During the data call in 2023, both sets of data were collected through the GLASS information technology platform, which provides access to all GLASS databases with unique authentication and rights management. Countries can use the GLASS-AMU data collection template, a standardized Excel® data collection form, the most recent ATC/DDD index and macros for data validation, calculation of AMU in DDD, and data extraction for submission to GLASS *(22)*.

The GLASS-AMU helpdesk supports countries in preparing, validating and uploading data onto the platform. The GLASS AMU team analyses and validates the data against that of previous years (when available) and prepares and shares a country validation report for approval by the country before data publication. At this stage, consensual decisions are taken with countries on whether to include the data in GLASS publications. Reasons for excluding data include: (i) concern about the internal quality of the data due to issues during data collection, such as inconsistent recording of the number of medicine products used in 1 year; and (ii) collection of data from a limited, non-representative proportion of sources, resulting in estimated coverage of < 50% of a country's AMU.

2.3 Data analysis

This report first presents global progress in the number of CTAs reporting to GLASS-AMU in the 2021, 2022 and 2023 data calls and provides an overview of the data available on the GLASS dashboard for 2016–2022 for each targeted antimicrobial class.

The report then provides AMU in 2022 reported by 60 CTAs. It presents the characteristics of the data, including the type of data, the coverage and disaggregation by levels and sectors of care and the overall coverage of the AMU data reported. It subsequently summarizes AMU aggregated for all care (in communities and hospitals and in the public and private sectors), with exceptions specified in notes. The antibiotics are classified, and the volume of AMU is calculated in DDD according to the 2023 ATC/DDD index version. To adjust for population size to allow comparisons of AMU data among CTAs, use is presented as DID. Details of the indicators used and on how they are calculated are provided in Annex 2.

Although the GLASS-AMU method provides a standardized framework for global data collection, reporting and analysis, variation in its application by CTAs and certain limitations in the method or classifications may affect the accuracy and comparability of the reported patterns of AMU. Annex 3 lists the main limitations to be considered in interpreting the data.

3. Progress in global participation in GLASS-AMU

By the end of 2023, 90 (41.7%), of the 216 CTAs considered by GLASS had enrolled in GLASS-AMU, and 74 (34.3%) had submitted AMU data to GLASS at least once in the calls for data in 2021–2023 (Fig. 1).

Since the first data call in 2021, the number of CTAs enrolled and reporting data to GLASS-AMU has increased steadily (Fig. 2). The number enrolled rose from 36 (16.7% of the 216 CTAs considered by GLASS) in 2021 to 78 (36.1%) in 2022 and was 90 (41.7%) by the end of 2023. The number of CTAs that submit data to GLASS increased from 27 (12.5%) in 2021 to 61 (28.2%) in 2022 and to 66 (30.6%) after the 2023 data call. Some CTAs enrolled in GLASS-AMU, however, still lack surveillance systems that can provide national data on AMU annually or do not meet minimum quality standards. Eight CTAs, representing 12.5% of the 64 CTAs that reported AMU data in the previous two data calls, did not participate in the 2023 data call. Additionally, two CTAs that reported data during the 2023 data call provided data only from before 2022.

Overall, of the 74 CTAs that participated in one of the three data calls, 67 had AMU data published in GLASS-AMU for at least 1 year during 2016–2022, representing 31% of the 216 CTAs; of these, 60 CTAs (27.8%) provided data for 2022 (Table 1). Data reported by seven countries were excluded from publication because of poor quality.

Although participation increased, the representativeness of participation and data coverage were unbalanced among WHO regions and income groups. The highest relative participation was observed in the Eastern Mediterranean Region, with 81.8% of CTAs enrolled (18/22). Participation exceeds 50% in both the South-East Asian (54.4%, 6/11) and the European regions (61.8%, 34/55). The Region of the Americas has the lowest participation in both absolute and relative terms, with 8.9% of CTAs enrolled (4/45). With respect to income level, the highest relative enrolment is of low-income countries, 50.0% of which are enrolled (13/26), while the lowest level is of upper–middle-income countries with 33.3% of enrolled (18/54).

In cumulative data for the period 2016–2022, the highest proportion of CTAs that report data is in the European Region (61.8%, 34/55) and the lowest proportion in the Region of the Americas (6.7%, 3/45). With respect to income level, the highest proportion of CTAs that report data is among high-income CTAs (44.9%, 35/78) and the lowest is among low-income CTAs (26.9%, 7/26).

Fig. 1. CTA enrolment and participation in GLASS-AMU by the end of 2023

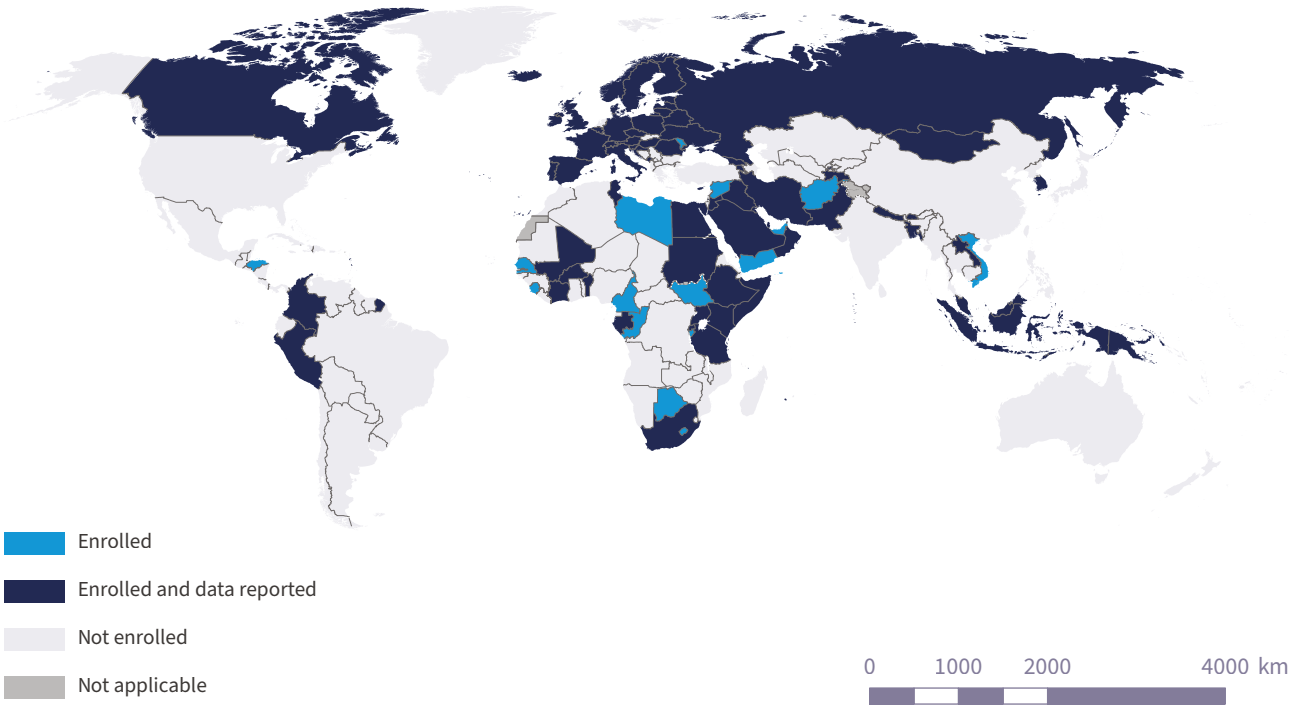


Fig. 2. Progress in enrolling in and reporting AMU data to GLASS among 216 CTAs after the 2021, 2022 and 2023 data calls

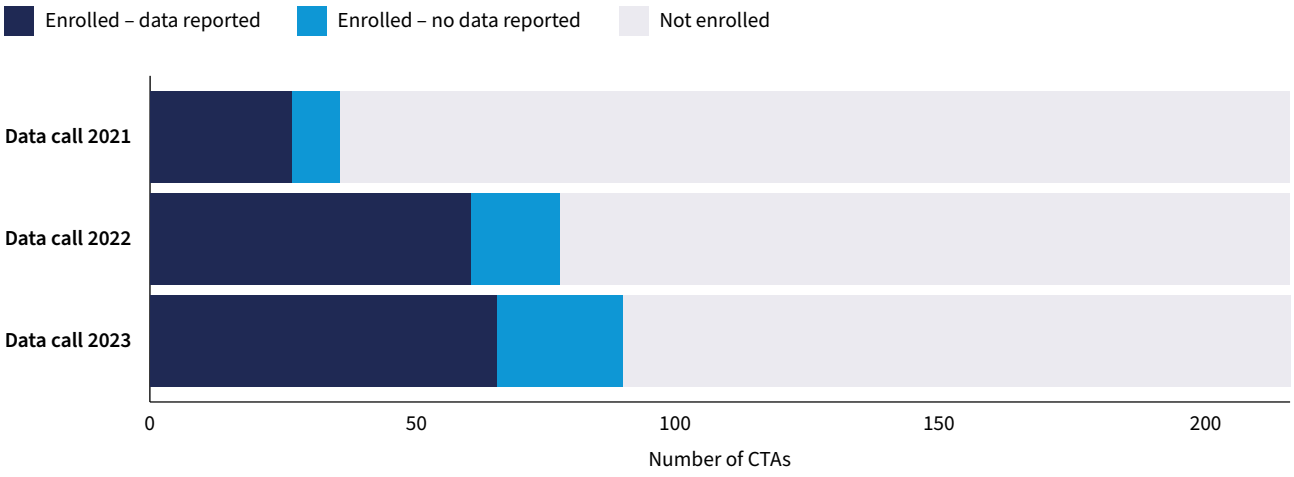


Table 1. CTAs that participated and reported data to GLASS-AMU by December 2023 by WHO region and World Bank income group classification

	Total CTAs	CTAs enrolled in GLASS-AMU	CTAs with 2016–2022 data reported (at least 1 year)	CTAs with 2016–2022 data published (at least 1 year)	CTAs with data published in 2022
	n	n (%)	n (%)	n (%)	n (%)
World	216	90 (41.7)	74 (34.3)	67 (31)	60 (27.8)
WHO regions					
African Region	47	19 (40.4)	11 (23.4)	11 (23.4)	8 (17)
Region of the Americas	45	4 (8.9)	3 (6.7)	3 (6.7)	3 (6.7)
South-East Asia Region	11	6 (54.5)	6 (54.5)	5 (45.5)	4 (36.4)
European Region	55	34 (61.8)	34 (61.8)	33 (60)	32 (58.2)
Eastern Mediterranean Region	22	18 (81.8)	13 (59.1)	10 (45.5)	9 (40.9)
Western Pacific Region	36	9 (25.0)	7 (19.4)	5 (13.9)	4 (11.1)
Income level[a]					
High income	78	37 (47.4)	35 (44.9)	34 (43.6)	32 (41)
Upper–middle income	54	18 (33.3)	16 (29.6)	12 (22.2)	11 (20.4)
Lower–middle income	51	22 (43.1)	16 (31.4)	15 (29.4)	13 (25.5)
Low income	26	13 (50.0)	7 (26.9)	6 (23.1)	4 (15.4)

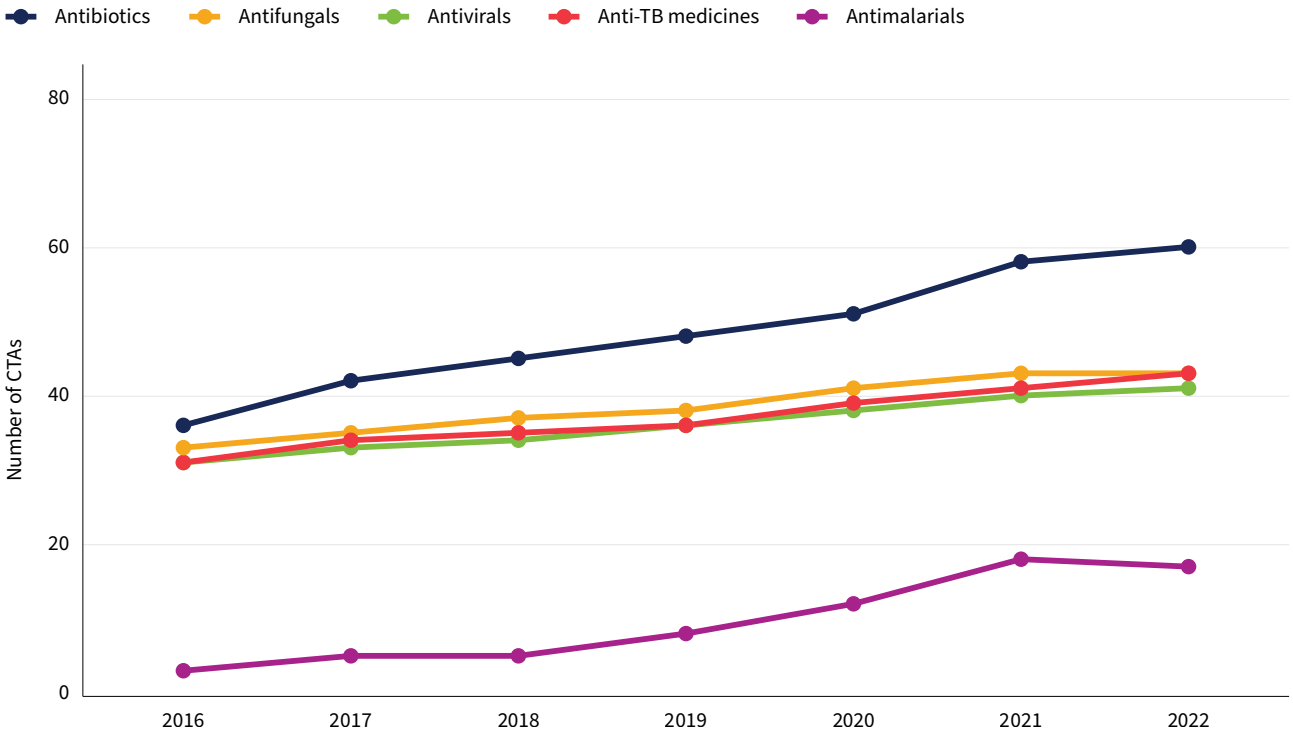
[a] Source: World Bank (2022) *(23)*

Seven CTAs were excluded because no information was available to classify them.

The percentages in the table represent the proportion of CTAs relative to the total number of CTAs and the number in each WHO region and by income level.

Increasing numbers of CTAs are participating and reporting data on a growing number of antimicrobial classes (Fig. 3). The number of CTAs that provided data on antibiotics increased from 36 in 2016 to 60 in 2022. Additionally, 43 CTAs reported 2022 data on antifungals and antituberculosis medicines, and 41 CTAs reported 2022 data on antivirals. Data on antimalarials, which are particularly relevant in malaria-endemic countries, were reported by 17 CTAs in 2022.

Fig. 3. Numbers of CTAs that published data on use of the five targeted antimicrobial classes *(2016–2022)*



4. Antibiotic use in 2022

Data on antibiotic use in 2022 are presented for 60 CTAs, representing 27.8% of all 216 CTAs and covering approximately 1.74 billion people, or about 22.1% of the global population.

4.1 Data characteristics

Table 2 summarizes the characteristics of the 2022 AMU data included in the report. For most CTAs, 2022 AMU data represent distribution or wholesale data (36.7%, n=22/60), except in the European Region, where dispensing and reimbursement data prevail (40.6%, n=13/32). Most of the data reported (85.0%, n=55/60) cover all sectors of care (i.e. total care), the European Region having the highest coverage at 93.8% (30/32). Only 44.3% of CTAs (29/60) reported data disaggregated by community and hospital; the European Region had the highest percentage (81.2%, n=26/32). One CTA in the African Region reported data disaggregated by public and private sectors. The estimated national coverage of the data reported was ≥ 90% for 81.7% of the CTAs (49/60); European Region coverage was 93.9% (30/32).

Table 2. Characteristics of data on AMU in 60 CTAs in 2022, globally and by WHO region

	Global	African Region	Region of the Americas	South-East Asia Region	European Region	Eastern Mediterranean Region	Western Pacific Region
Number of CTAs	60	8	3	4	32	9	4
Data characteristics	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Type of data							
Dispensing/reimbursement	17 (28.3)	0 (0.0)	2 (66.7)	0 (0.0)	13 (40.6)	2 (22.2)	0 (0.0)
Distribution/wholesale	22 (36.7)	5 (62.5)	0 (0.0)	2 (50.0)	10 (31.2)	3 (33.3)	2 (50.0)
Import/Local manufacture	15 (25.0)	3 (37.5)	1 (33.3)	2 (50.0)	4 (12.5)	4 (44.4)	1 (25.0)
Mixed level	6 (10.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (15.6)	0 (0.0)	1 (25.0)
Health care coverage							
Total health-care coverage[a]	51 (85.0)	6 (75.0)	2 (66.7)	4 (100)	30 (93.8)	6 (66.7)	3 (75.0)
Public care	8 (13.3)	2 (25.0)	1 (33.3)	0 (0.0)	1 (3.1)	3 (33.3)	1 (25.0)
Community care	1 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.1)	0 (0.0)	0 (0.0)
Data disaggregation							
Fully aggregated	30 (50)	7 (87.5)	2 (66.7)	4 (100)	6 (18.8)	7 (77.8)	4 (100)
Disaggregated community and hospital	29 (48.3)	0 (0.0)	1 (33.3)	0 (0.0)	26 (81.2)	2 (22.2)	0 (0.0)
Disaggregated private and public	1 (1.7)	1 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
AMU volume covered[b]							
> 90%	49 (81.7)	5 (62.5)	2 (66.7)	4 (100)	30 (93.8)	5 (55.6)	3 (75)
80–89%	4 (6.7)	2 (25)	0 (0.0)	0 (0.0)	2 (6.2)	0 (0.0)	0 (0.0)
> 60–79%	7 (11.7)	1 (12.5)	1 (33.3)	0 (0)	0 (0)	4 (44.4)	1 (25)
Unknown	5 (7.5)	2 (18.2)	0 (0.0)	0 (0.0)	1 (3)	0 (0.0)	2 (40)

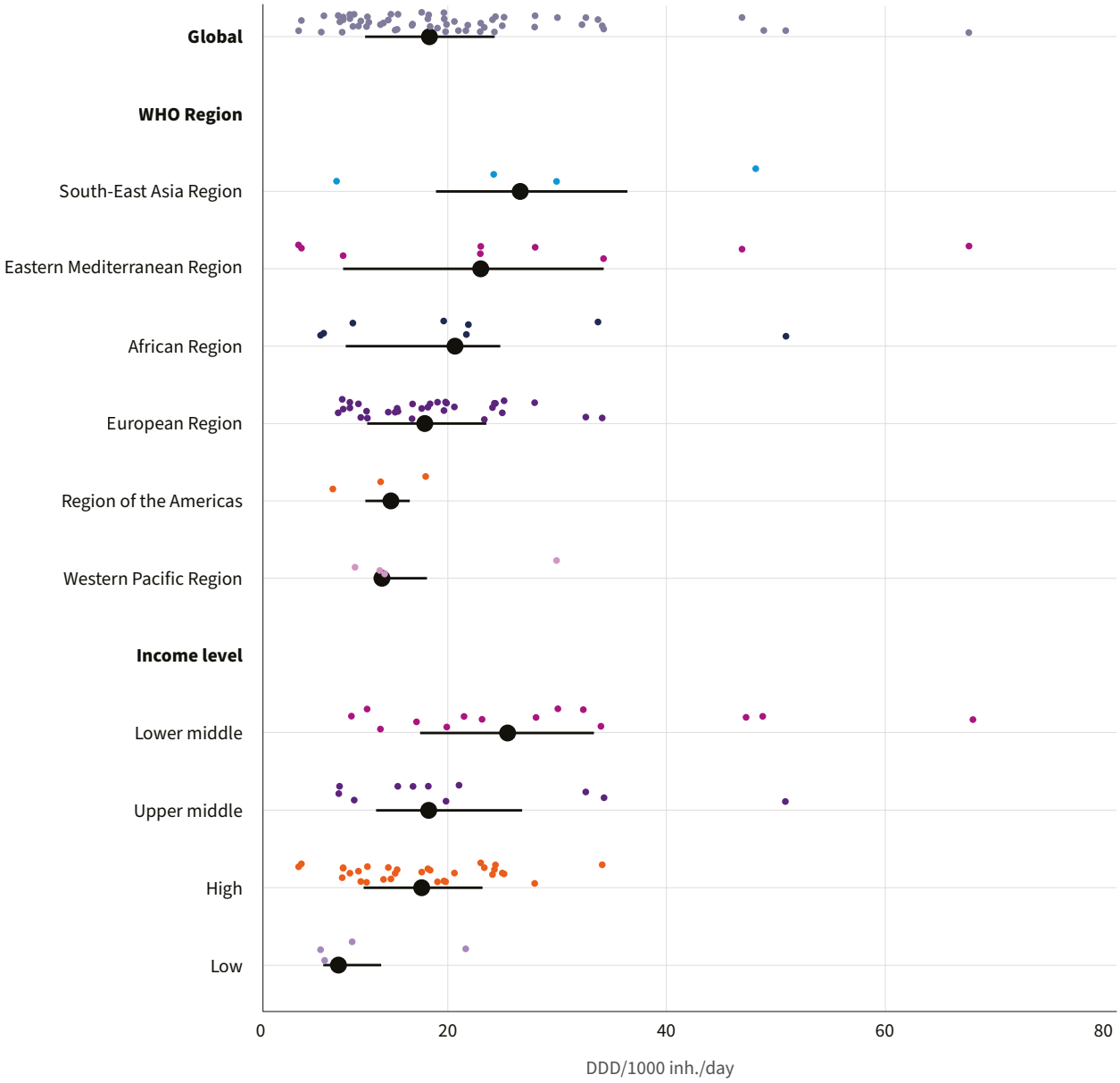
[a] Total care: the data cover all sectors (public and private) and levels (community and hospital) of care.

[b] AMU volume coverage: estimated proportion of the national m-AMU volume of the data in the report (in some cases after adjustment by population coverage). WHO estimate based on completeness of m-AMU estimates reported by CTAs on the "data questionnaire".

4.2 Overall antibiotic use

The AMU data reported by the 60 CTAs for 2022 represented a total of 16.6 billion DDDs. The median total antibiotic use was 18.3 DID, ranging from 7.7 DID in Oman to 67.7 DID in the Islamic Republic of Iran (interquartile range [IQR]: 12.4–24.3) (Fig. 4). Antibiotic use was higher among CTAs in the South-East Asian (26.6 DID [IQR: 18.9–36.4]) and Eastern Mediterranean (23.0 DID [IQR: 10.4–34.3]) regions and among LMIC (25.5 DID [IQR: 17.5–33.4]). The lowest level of use was in low-income CTAs (10 DID [IQR: 8.6–13.9]), although in half (2/4) of these CTAs, the reported volume is known to represent < 90% of the estimated use.

Fig. 4. Total antibiotic use expressed as DID in 60 CTAs in 2022, globally, by WHO region and by World Bank income group classification



Each coloured dot represents one CTA. The large black dot represents the median, and the lines represent the interquartile range. In 13 CTAs, the data shown represent < 90% of use in the CTA; in Kuwait, Oman, Papua New Guinea, Peru, Rwanda, Saudi Arabia and South Africa, the data represent the public sector only; in Germany, the data represent use in the community only; and in Mali, occupied Palestinian territory, including east Jerusalem and Qatar, the data represent total care but were collected from sources covering < 90% of the national antibiotic market.

4.3 Antibiotic use by WHO AWaRe classification

Member States endorsed the GPW 2023 60% Access target in November 2022 at the Third Global High-level Ministerial Conference on AMR *(24)* and committed to an even more ambitious target, the UNGA 2030 70% Access target, at the UN General Assembly High-level Meeting on antimicrobial resistance in October 2024 *(16)*.

Of the reported 16.6 billion DDD in 2022, 52.7% were of Access antibiotics, and thus below the GPW 2023 60% Access target and the UNGA 2030 70% Access target, and 45.3% were Watch antibiotics. Reserve antibiotics accounted for 0.3%, while Not classified or Not recommended antibiotics represented 1.7% (Fig. 5).

In the analysis of the proportional distribution of different AWaRe classes among CTAs, Access antibiotics accounted for a median of 62.5% of national use (IQR: 50.8–71.9, range: 18.2–89.8%) (Fig. 6), representing a median use of 11.5 DID (IQR: 7.3–14.5, range: 3.8–42.8%). The median proportion of Watch antibiotics use was 33.3% (IQR: 27.2–45.1, range: 10.2–71.3%), representing a median use of 6.0 DID (IQR: 3.7–10.5, range: 1.2–36%).

Eight of the 60 CTAs (13.3%) reported no use of antibiotics in the Reserve group. Of these, two were low-income and six LMICs, representing 47.1% (8/17) of the CTAs in these two income classes that reported data, possibly indicating poor access to Reserve antibiotics in resource-limited settings. Among the 86.7% of CTAs (52/60) that reported any use of Reserve antibiotics, the median relative use was 0.2% (IQR: 0.1–0.4, range: 0.0–1.7%) or 0.2 DID (IQR: 0.1–0.4). Use of Not classified or Not recommended antibiotics was reported by 75% of the CTAs (45/60), with a median relative use of 0.6% (IQR: 0.0–1.9, range: 0.0–16.9%). In five CTAs, their relative use was > 5%. The median use in the 45 CTAs was 0.1 DID (IQR: 0.0–0.6; range, 0–5.5%).

Globally, 58% (35/60) of the CTAs met the GPW 2023 60% Access target and 31.7% (19/60) also met the UNGA 2030 70% Access target (Table 3). Lower proportions of CTAs in the South-East Asia and Eastern Mediterranean regions, in LMIC and upper–middle-income countries and in those with high total levels of antibiotic use (i.e. > 75th percentile) achieved these targets (Table 3, Fig. 7). Although the data indicate that CTAs with higher levels of use tended to use a fewer Access and more Watch antibiotics, they also show that the Access targets were achieved at widely different levels of overall antibiotic use (Fig. 6). This suggests that indicators and targets that include overall use are required.

Fig. 5. Proportion of the global volume of antibiotics reported by 60 CTAs in 2022 by WHO AWaRe classification

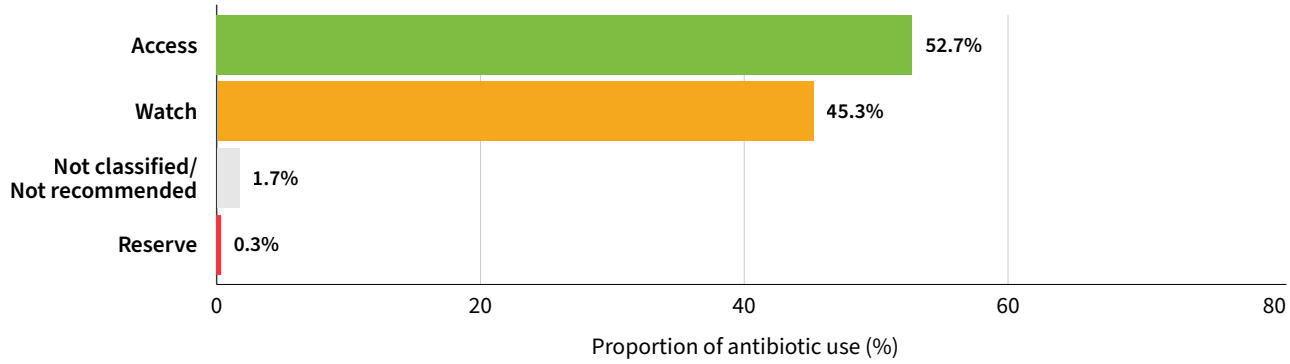
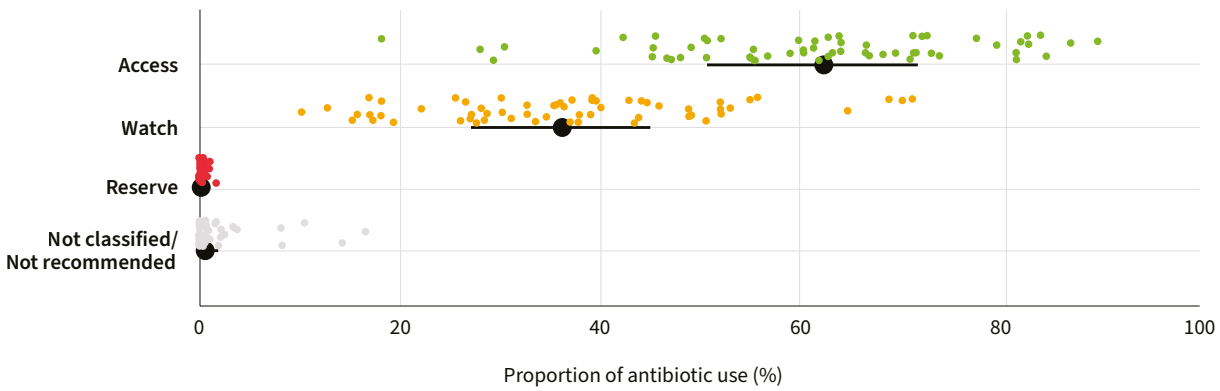


Fig. 6. Distribution of proportional antibiotic use by AWaRe classification in 60 CTAs in 2022



Each coloured dot represents one CTA. The large black dot represents the median, and lines represent the interquartile range.

Table 3. Achievement of the GPW 2023 60% Access target and the UNGA 2030 70% Access target, by WHO region, World Bank income group classification and level of antibiotic use in 60 CTAs in 2022

	CTAs included in the report n	CTAs that attained the GPW 2023 60% Access target n (%)	CTAs that attained the UNGA 2030 70% Access target n (%)
Total	60	35 (58.3)	19 (31.7)
WHO regions			
African Region	8	5 (62.5)	5 (62.5)
Region of the Americas	3	3 (100)	1 (33.3)
South-East Asia Region	4	1 (25)	1 (25)
European Region	32	18 (56.2)	9 (28.1)
Eastern Mediterranean Region	9	4 (44.4)	1 (11.1)
Western Pacific Region	4	4 (100)	2 (50)
Income level			
High income	31	22 (71)	11 (35.5)
Upper middle	11	5 (45.5)	2 (18.2)
Lower middle	14	6 (42.9)	4 (28.6)
Low	4	2 (50)	2 (50)
Total antibiotic use (percentile			
< 25th	15	11 (66.7)	6 (40.0)
25th–75th	30	20 (73.3)	11 (36.7)
> 75th	15	4 (26.7)	2 (13.3)

Fig. 7. Use of Access antibiotics and total use expressed in DDD per 1000 inhabitants per day in 60 CTAs in 2022

3-letter ISO codes[1] are used for country names. In 13 CTAs, the data represent less than 90% of use: in Kuwait (KWT), Oman (OMN), Papua New Guinea (PNG), Peru (PER), Rwanda (RWA), Saudi Arabia (SAU) and South Africa (ZAF), the data represent the public sector only; in Germany (DEU), the data represent use in the community only; and for Mali (MLI), occupied Palestinian territory, including east Jerusalem (PSE) and Qatar (QAT), the data represent total care but were collected from sources that cover < 90% of the national antibiotic market[1].

[1] ISO 3166 — Country Codes. Geneva: International Organization for Standardization (https://www.iso.org/iso-3166-country-codes.html).

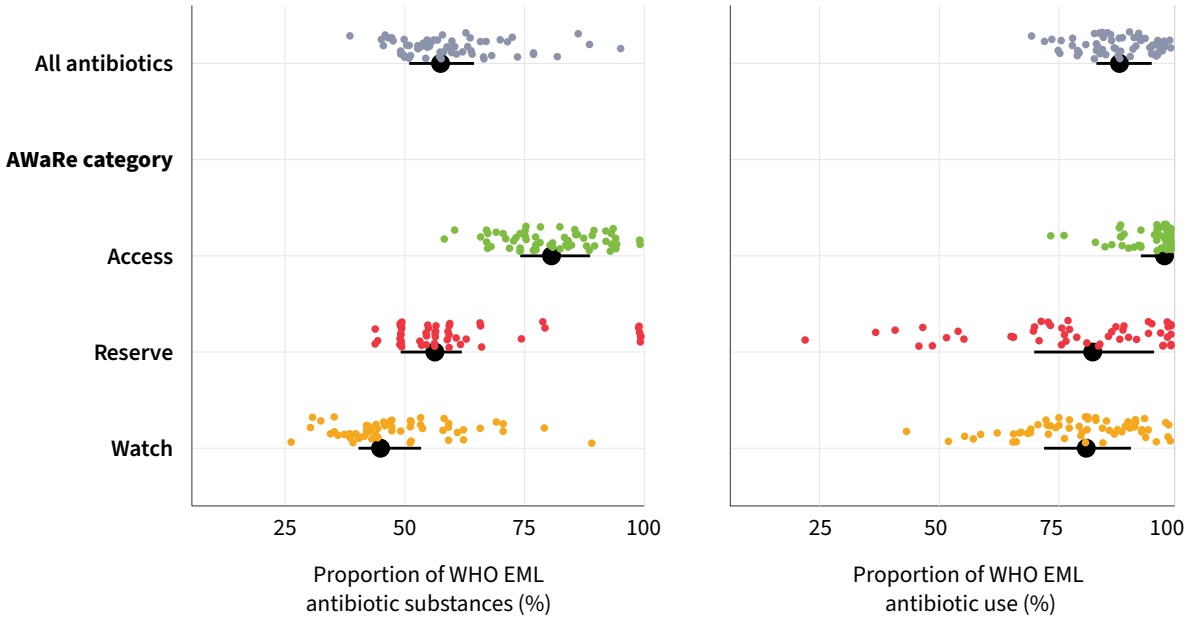
4.4 Antibiotic use according to the WHO EML

The WHO EML lists the safest, most effective medicines for the priority health needs of populations and is used to guide countries in developing their own EMLs. With introduction of the AWaRe classification in 2017, the WHO EML is also a guide for revision of national lists by prioritizing antibiotic to optimize antibiotic use *(12)*.

The 2023 version of the WHO EML includes 41 antibiotics (not including antibiotics used mainly for the treatment of tuberculosis) and nine additional antibiotics proposed as therapeutic alternatives: 26 Access, 14 Watch and 10 Reserve antibiotics *(17)*. Of the 167 antibiotics represented in data reported to GLASS for 2022, 47 (28.1%) were on the WHO EML, accounting for 89% of total reported antibiotic volume. No use of two WHO EML substances was reported: Access methicillin, a therapeutic alternative to cloxacillin, and the Reserve antibiotic plazomicin, which was not marketed at the time because of failed commercialization *(25)*.

WHO EML antibiotics represented a median of 58% of the antibiotics reported by the 60 CTAs (IQR: 51.8–65.4, range: 39.4–96%) and 88.9% of the CTAs' antibiotic use volume (IQR: 83.9–95.9, range: 69.8–100) (Fig. 8). The relative number and volume of use of WHO EML antibiotics were higher for the Access group, at 81.5% (IQR: 75–89.6, range: 59.1–100%) and 98.6% (IQR: 93.5–99.7, range: 74–100%), respectively. In contrast, the smallest relative number of WHO EML antibiotics was in the Watch group, 45.8% (IQR: 41.2–54.3, range: 27.1–90), and a median WHO EML antibiotics proportion of use of 81.7% (IQR: 72.5–91.4, range: 42.8–99.9). For the Reserve group, the median proportion of WHO EML substances was 57.1% (IQR: 50–62.8, range: 44.4–100), with a median relative use of 83.1% (IQR: 70.4–96.4, range: 20.8–100). Not classified or Not recommended antibiotics are systematically excluded from the WHO EML and are therefore not shown in the AWaRe groups in Fig. 8.

Fig. 8. Antibiotic use according to the WHO EML, for all antibiotics and by AWaRe classification in 60 CTAs in 2022



Not classified or Not recommended antibiotics are not shown io the figure as they are systematically not included on the WHO EML. Each coloured dot represents one CTA. The large black dot represents the median, and lines represent the interquartile range.

4.5 Patterns of use of different antibiotics

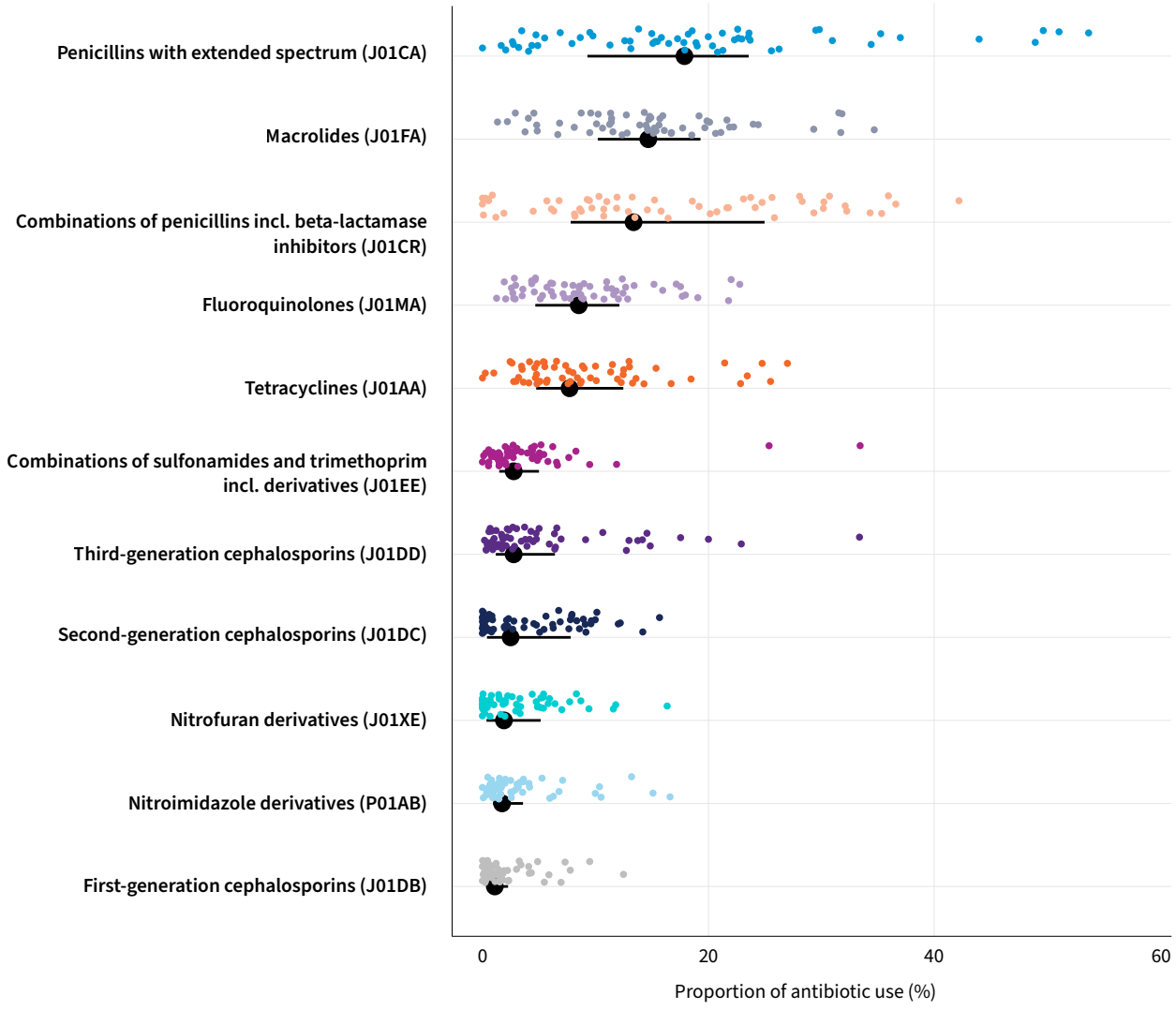
4.5.1 Use by antibiotic subgroup

In the ATC classification system, drugs are organized into groups according to their therapeutic use and chemical composition. For antibiotics, the ATC4 level specifies classes or subclasses by their pharmacological properties, chemical structure or mechanisms of action *(18)*.

In 2022, 11 ATC4 antibiotic subgroups of the 34 considered by GLASS collectively accounted for > 90% of reported antibiotic use. The median proportional use is shown in Fig. 9. The highest median proportional use was of extended-spectrum penicillins (17.9%; IQR: 9.3–23.6, range: 0.0–53.7%), and they were the most frequently used antibiotics in 35% of CTAs (21/60). Macrolides (all in the Watch category) were the next most frequently used, with a median proportional use of 14.7% (IQR: 10.2–19.3, range: 1.3–34.7%). Antibiotics from this subgroup were the most used in 15% of the CTAs (9/60) and accounted for approximately 18% of all DDDs reported globally. The median proportional use of combinations of penicillins, including beta-lactamase inhibitors, was 13.4% (IQR: 7.8–28, range: 0–42.2%), and they were the most frequently used antibiotics in 33% of CTAs (20/60).

Other frequently used ATC4 subgroups were fluoroquinolones and tetracyclines, with similar proportional use. Fluoroquinolones, all Watch antibiotics, were the most frequently used subgroup in 5% of CTAs (3/60), with a median proportional use of 8.5% (IQR: 4.7–12.1, range: 1.2–22.8%). The median proportional use of tetracyclines was 7.7% (IQR: 4.8–12.5, range: 0–27%), and they were the most frequently used subgroup of antibiotics in three high-income countries. Although the overall median proportional use of combinations of sulfonamides and trimethoprim, including derivatives, was < 5.5% in 75% of CTAs, they were the most frequently used antibiotics in two countries in the African Region, presumably because of their use in preventing opportunistic infection in people living with HIV.

Fig. 9. Proportional antibiotic use by pharmacological subgroup (ATC4) in 60 CTAs in 2022

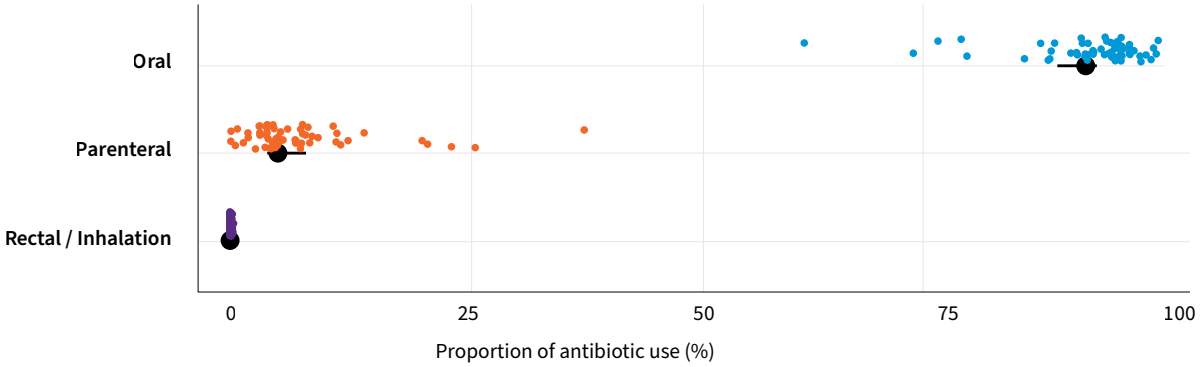


Each coloured dot represents one CTA. The large black dot represents the median and lines represent the interquartile range.

4.5.2 Antibiotic use by route of administration

Oral formulations are the preferred choice in primary care and may therefore be used as a surrogate for community use. Oral antibiotic formulations accounted for 94.2% of the total volume reported globally, with a median proportional use of 94.8% (IQR: 91.8–96; range: 61.9–99.9%) (Fig. 10). Use of parenteral antibiotics accounted for a median proportional use of 5.2% of the total AMU volume (IQR: 4–8.2; range: 0.1–38.1%). In 10% (6/60) of CTAs, use of parenteral antibiotics was > 25%. Rectal and inhalation formulations accounted for < 1% of total AMU volume, with a median proportional use of 0.0% (IQR: 0.0–0.1; range: 0.0–0.4%).

Fig. 10. Proportional distribution of antibiotic use by route of administration in 60 CTAs in 2022



Use of oral antibiotic formulations

In 2022, use of 109 different oral antibiotics was reported globally. Analysis of the antibiotics that constituted 75% of the oral use volume (DU75) in CTAs in 2022 showed that 34 antibiotics appeared at least once in the DU75 of the 60 CTAs, and seven ranked first in at least one CTA. The number of antibiotics constituting the DU75 for oral substances ranged from 2 to 10 among CTAs, with a median of 6. Table 4 and Fig. 11 summarize the patterns of the most frequently used oral antibiotics (i.e. those in the DU75 of at least three CTAs).

The two Access antibiotics amoxicillin and amoxicillin combined with a beta-lactamase inhibitor (predominantly amoxicillin–clavulanic acid) were the most frequently used oral antibiotics. Amoxicillin alone (J01CA04) was the most frequently used oral substance, with a median relative use of 16.8% (IQR: 6.9–23.7; range: 0.0–57.4%). It was the most frequently used oral antibiotic in 43.3% (26/60) of the CTAs and was in the oral DU75 of 88.3% (53/60) CTAs. The median relative use of amoxicillin combined with a beta-lactamase inhibitor (J01CR02), the most frequently used oral antibiotic in 35% (21/60) CTAs, was 12.7% (IQR: 5.1–26.1; range: 0.0–37.1%).

Azithromycin and doxycycline were also used frequently. Azithromycin, a Watch group macrolide, was the most frequently used oral antibiotic in 8.3% (5/60) CTAs, all of which were upper- or lower–middle-income CTAs; the median proportional use was 8.8% (IQR: 5.1–14.3; range: 0.0–32.2%). Doxycycline, an Access tetracycline, was the most frequently used antibiotic in two high-income countries, with a median proportional oral use of 7.4% (IQR: 4.2–12.4; range: 0.0–25.8%).

Other substances in the oral DU75 in over 25% (n=15) of CTAs were the Watch antibiotics ciprofloxacin (fluoroquinolone), clarithromycin (macrolide) and cefuroxime (second-generation cephalosporin); the Access antibiotics sulfamethoxazole and trimethoprim as a fixed-dose combination (the most frequently used substances in three CTAs); and nitrofurantoin, an antibiotic indicated exclusively for treatment of lower urinary tract infections.

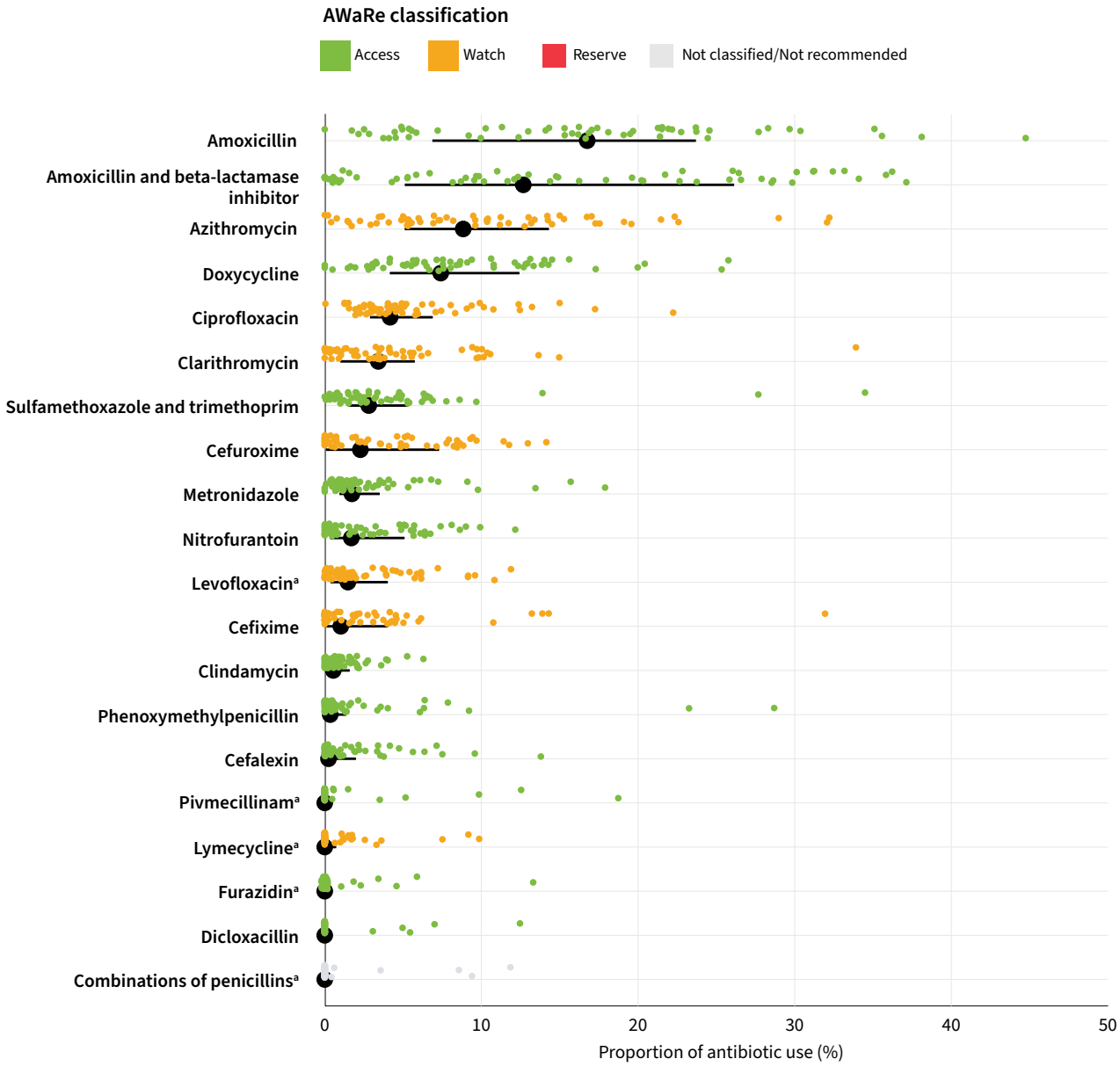
Table 4. Pattern of use of oral antibiotics in 60 CTAs in 2022

		CTAs that reported use of the antibiotic			
		In the DU75	In the first three	First one	With any use reported
	Antibiotic	n (%)	n (%)	n (%)	n (%)
●	Amoxicillin	53 (88.3)	43 (71.7)	26 (43.3)	59 (98.3)
●	Amoxicillin and beta-lactamase inhibitor	43 (71.7)	35 (58.3)	21 (35)	56 (93.3)
●	Azithromycin	46 (76.7)	29 (48.3)	5 (8.3)	59 (98.3)
●	Doxycycline	41 (68.3)	19 (31.7)	2 (3.3)	58 (96.7)
●	Ciprofloxacin	24 (40)	9 (15)	0 (0)	60 (100)
●	Clarithromycin	23 (38.3)	7 (11.7)	0 (0)	58 (96.7)
●	Cefuroxime	23 (38.3)	4 (6.7)	0 (0)	53 (88.3)
●	Sulfamethoxazole and trimethoprim	18 (30)	4 (6.7)	3 (5)	59 (98.3)
●	Nitrofurantoin	15 (25)	2 (3.3)	0 (0)	52 (86.7)
●	Levofloxacin[a]	13 (21.7)	3 (5)	0 (0)	54 (90)
●	Cefixime	11 (18.3)	5 (8.3)	1 (1.7)	45 (75)
●	Metronidazole	9 (15)	5 (8.3)	0 (0)	57 (95)
●	Phenoxymethylpenicillin	8 (13.3)	2 (3.3)	2 (3.3)	47 (78.3)
●	Cefalexin	7 (11.7)	1 (1.7)	0 (0)	48 (80)
●	Pivmecillinam[a]	5 (8.3)	1 (1.7)	0 (0)	11 (18.3)
●	Clindamycin	4 (6.7)	1 (1.7)	0 (0)	52 (86.7)
●	Furazidin[a]	3 (5)	3 (5)	0 (0)	7 (11.7)
●	Lymecycline[a]	3 (5)	1 (1.7)	0 (0)	19 (31.7)
●	Combinations of penicillins[a]	3 (5)	1 (1.7)	0 (0)	11 (18.3)
●	Dicloxacillin	3 (5)	1 (1.7)	0 (0)	7 (11.7)

[a] The antibiotic is not included in the WHO EML *(17)*. Oral levofloxacin is listed on the WHO EML only for the treatment of multidrug-resistant tuberculosis.

Only antibiotics in the oral DU75 of at least 5% of the CTAs (n=3) are shown in the table. They are listed according to the number of CTAs in which the antibiotic was included in the DU75. The dots next to the names are coloured according to the AWaRe classification: Access (green), Watch (yellow), Reserved (red) and Not classified or Not recommended (grey).

Fig. 11. Proportional use of the most frequently used oral antibiotics in 60 CTAs in 2022



[a] The antibiotic is not included in the WHO EML *(17)*.
Only antibiotics in the oral DU75 of at least 5% of the CTAs (n=3) are included in the figure. Each coloured dot represents one CTA. The large black dot represents the median proportion of oral use, and lines represent the interquartile range.

Use of parenteral antibiotic formulations

In 2022, use of 92 parenteral antibiotics was reported globally. They included 26 (28.2%) Access antibiotics, 43 (46.7%) Watch antibiotics, 18 (19.6%) Reserve antibiotics and 5 (5.4%) Not classified or Not recommended. Analysis of antibiotics on the CTA 2022 parenteral DU75 showed significant variation among the 60 CTAs. The number of DU75 parenteral antibiotics ranged from 1 to 12 (median, 6); 39 substances appeared at least once in the parenteral DU75, and 15 ranked first (Table 5).

In 66.7% (40/60) of CTAs, the most frequently used parenteral antibiotics were in the Watch group. Third-generation cephalosporins were the most frequently used parenteral antibiotics in 58% of CTAs (35/60); ceftriaxone was the most frequently used parenteral antibiotic in 55% of CTAs (33/60); and cefotaxime was used in 3.3% (2/60). Overall, ceftriaxone was the most frequently used parenteral antibiotic, with a median proportional use of 21.2% (IQR: 7.2–34.3; range: 0–77.6%) (Fig. 12). Combinations of penicillins with beta-lactamase inhibitors ranked first in 21.7% of CTAs (13/60), and amoxicillin combined with a beta-lactamase inhibitor ranked first in 16.7% of CTAs (10/60).

Three Access beta-lactamase-resistant penicillins (flucloxacillin, oxacillin and cloxacillin) were the most widely used parenteral antibiotics in four CTAs, and three beta-lactamase-sensitive penicillins (benzathine benzylpenicillin, procaine benzylpenicillin and

benzylpenicillin) ranked first in three lower–middle- and low-income CTAs. Cefuroxime, a second-generation cephalosporins, was the most frequently used antibiotic in two CTAs in the European Region. The first-generation cephalosporin cefazolin was the most frequently used antibiotic in one CTA, with the third highest median use (4.7%, IQR: 0.2-8.5, range: 24.6). Parenteral metronidazole was in the DU75 of most CTAs, and the median proportional use was 4.9% (IQR: 2.5-7.1, range: 20.3).

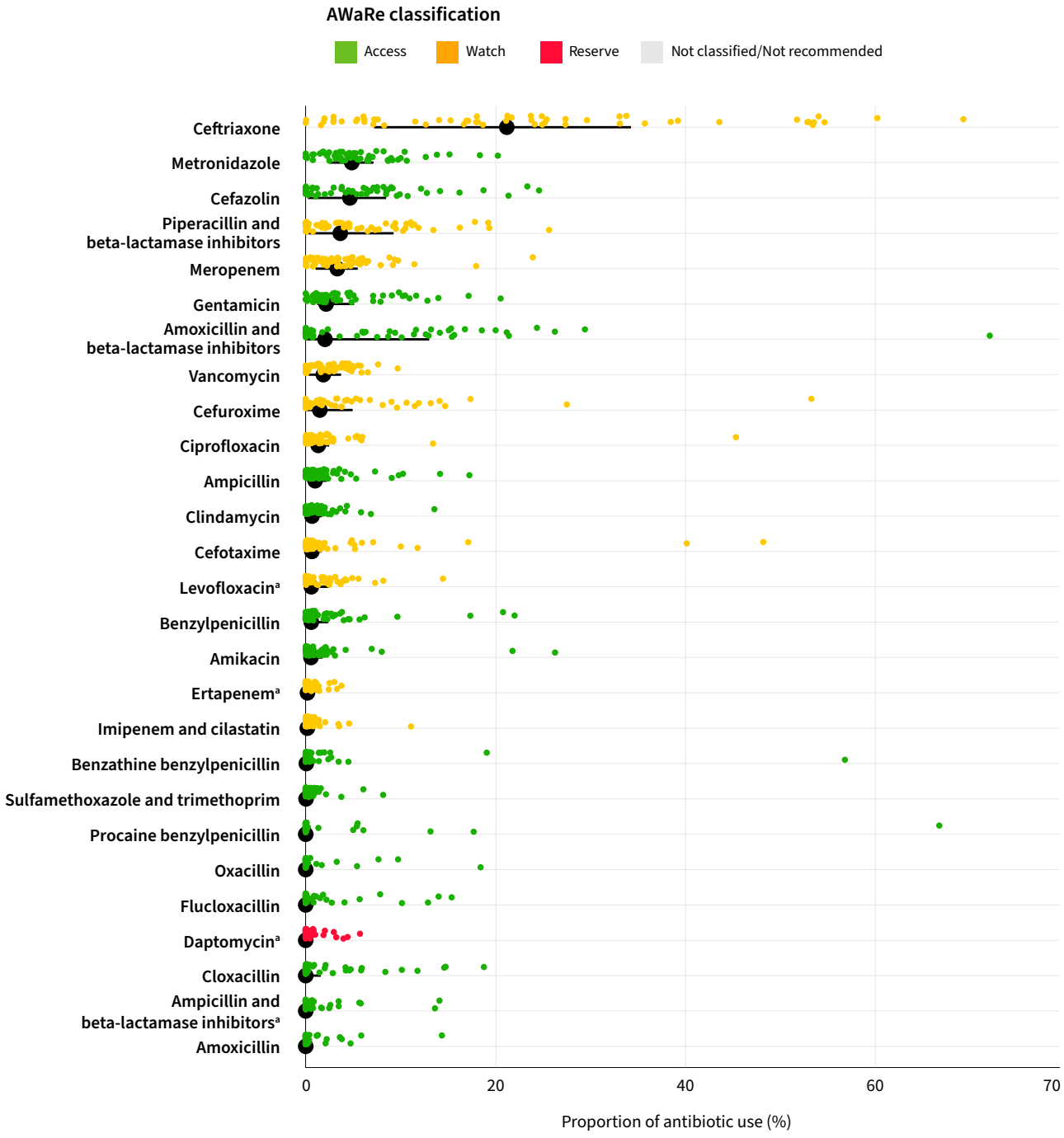
Table 5. Patterns of use of the most frequently used parenteral antibiotics in 60 CTAs in 2022

		CTAs in which the antibiotic was used (No. (%))			
		In the DU75	In the first three	First one	With any use reported
	Antibiotic	n (%)	n (%)	n (%)	n (%)
🟡	Ceftriaxone	51 (85)	41 (68.3)	33 (55)	59 (98.3)
🟢	Metronidazole	35 (58.3)	15 (25)	0 (0)	56 (93.3)
🟢	Cefazolin	33 (55)	11 (18.3)	1 (1.7)	51 (85)
🟢	Amoxicillin and beta-lactamase inhibitor	27 (45)	20 (33.3)	10 (16.7)	50 (83.3)
🟡	Meropenem	26 (43.3)	4 (6.7)	0 (0)	59 (98.3)
🟡	Piperacillin and beta-lactamase inhibitor	23 (38.3)	16 (26.7)	2 (3.3)	52 (86.7)
🟡	Cefuroxime	21 (35)	10 (16.7)	2 (3.3)	51 (85)
🟢	Gentamicin	18 (30)	9 (15)	0 (0)	56 (93.3)
🟡	Vancomycin	15 (25)	0 (0)	0 (0)	56 (93.3)
🟡	Cefotaxime	11 (18.3)	6 (10)	2 (3.3)	55 (91.7)
🟢	Cloxacillin	11 (18.3)	4 (6.7)	1 (1.7)	27 (45)
🟢	Benzylpenicillin	8 (13.3)	3 (5)	1 (1.7)	46 (76.7)
🟡	Ciprofloxacin	7 (11.7)	1 (1.7)	1 (1.7)	57 (95)
🟢	Flucloxacillin	7 (11.7)	3 (5)	2 (3.3)	22 (36.7)
🟢	Ampicillin	7 (11.7)	4 (6.7)	0 (0)	52 (86.7)
🟢	Clindamycin	7 (11.7)	0 (0)	0 (0)	45 (75)
🟡	Levofloxacin[a]	7 (11.7)	2 (3.3)	0 (0)	48 (80)
🟢	Amikacin	5 (8.3)	4 (6.7)	1 (1.7)	52 (86.7)
🟢	Ampicillin and beta-lactamase inhibitor[a]	5 (8.3)	2 (3.3)	1 (1.7)	29 (48.3)
🟢	Procaine benzylpenicillin	5 (8.3)	4 (6.7)	1 (1.7)	13 (21.7)
🟡	Imipenem and cilastatin	4 (6.7)	1 (1.7)	0 (0)	47 (78.3)
🟢	Amoxicillin	4 (6.7)	1 (1.7)	0 (0)	21 (35)
🟢	Oxacillin	4 (6.7)	3 (5)	1 (1.7)	15 (25)
🟡	Ertapenem[a]	3 (5)	0 (0)	0 (0)	38 (63.3)
🟢	Benzathine benzylpenicillin	3 (5)	2 (3.3)	1 (1.7)	44 (73.3)
🔴	Daptomycin[a]	3 (5)	0 (0)	0 (0)	34 (56.7)
🟢	Sulfamethoxazole and trimethoprim	3 (5)	1 (1.7)	0 (0)	34 (56.7)

[a] The antibiotic is not included in the WHO EML *(17)*.

Only antibiotics in the parenteral DU75 of at least 5% of the CTAs (n=3) are included in the table. Substances are listed according to the number of CTAs that included the antibiotic in the parenteral DU75. The dots next to the names of antibiotics are coloured according to the AWaRe classification: Access (green), Watch (yellow), Reserved (red) and Not classified or Not recommended (grey).

Fig. 12. Proportional use of the most frequently used parenteral antibiotics in 60 CTAs in 2022



[a] Antibiotics not included in the WHO EML *(17)*.

Only antibiotics in the parenteral DU75 of at least 5% of the CTAs (n=3) are included in the figure. Each coloured dot represents one CTA. The large black dot represents the median proportion of parenteral use, and lines represent the interquartile range.

5. Interpretation, next steps and conclusions

5.1 Interpretation and implications of findings

Enrolling in GLASS-AMU is the first step for CTAs to commit to contributing AMU data to WHO, facilitate exchanges among CTAs and other stakeholders and receive coordinated support from WHO and its partners. Moreover, by participating in GLASS, CTAs contribute to assessing progress towards international targets (such as the GPW 2023 60% Access target and the UNGA 2030 70% Access target) and benchmarking national use against that of countries with similar health systems and epidemiological, social and economic characteristics. By the end of 2023, 90 CTAs had enrolled in GLASS-AMU, and 74 had reported at least 1 year of data; 67 had reported data of acceptable quality for inclusion in GLASS publications.

The steady increase in the number of CTAs enrolled in GLASS-AMU represents a growing global commitment to improve the use of antimicrobials worldwide and to control the emergence and further spread of AMR. Additionally, more countries are reporting data on antifungals, antivirals, antituberculosis medicines and, to a lesser extent, antimalarials, particularly in regions where these diseases are endemic. Disparities in engagement and surveillance capacity remain, however, limiting the possibility of a comprehensive, global assessment of AMU. Participation is still unbalanced, with little engagement of CTAs in the WHO Region of the Americas. Fewer than half of the countries in the African and the Western Pacific regions regularly provide high-quality data. Consequently, the current GLASS database is skewed towards high-income and European countries. Nevertheless, contributions from 33 LMIC with new surveillance systems demonstrate the feasibility of establishing national AMU systems based on the GLASS-AMU method.

GLASS-AMU attempts to collect complete annual AMU data as close as possible to the point of actual use by people, disaggregated by health sector (public and private) and level (hospital and primary care). The method is designed to be flexible, to accommodate different national health and pharmaceutical systems and different availability of data. Countries can start contributing to GLASS-AMU with the data they have and improve their systems incrementally. This approach allows gradual enhancement of data reporting, balancing precision, coverage and data disaggregation. By collecting, analysing, interpreting and sharing data with relevant national stakeholders, CTAs can understand the usefulness of the data, ideally prompting commitments to improve data quality. Countries that have recently conducted national surveillance of AMU can improve the quality of the data by systematically including data validation, extending coverage when applicable and exploring the possibility of using data sources closer to the point of care, which more accurately reflect actual antibiotic use by patients, if the data maintain good coverage. For example, it may not be advantageous to change from use of import or manufacturing data to data on reimbursements if the latter cover only a small percentage of overall AMU.

The disadvantage of this flexible approach is introduction of heterogeneity into GLASS-AMU data among CTAs. The data for 2022 summarized in this report are a mix of data types and levels of coverage. Therefore, direct comparisons among countries should be made with such limitations in mind. Data collected from different sources along the value chain provide different levels of detail and precision about the use of antibiotics. For example, import and local manufacturing data may reflect production and procurement cycles rather than actual usage in a calendar year. Incomplete coverage and missing data can lead to biased estimates of antibiotic use. For instance, use only of public sector data may skew use patterns towards a subset of antibiotics procured by the government, which are usually those listed in the national EML and generally show over-representation of Access antibiotics. The availability only of community use data may result in underestimation of the use of parenteral formulations and fail to capture use of Reserve group antibiotics. The elements to be considered in interpreting the data are described in Annex 3.

Despite significant variation in the participation of CTAs in different regions and at different income levels, this analysis of antibiotic use in 2022 in 60 CTAs provides an overview of how antibiotics are used in the six WHO regions and in countries at four income levels. The analysis shows considerable variation in antibiotic use by region and by income level in all the indicators analysed. While some of the variation is due partly to differences in data characteristics and coverage, some probably reflects actual differences in procurement, prescribing, dispensing and use.

The median total use of antibacterials in 2022 was 18.3 DID (IQR: 14.4–24.3), with more than 10 times variation in use among CTAs with the lowest and the highest use (DID, 6.3–67.7) and considerable variation among and within all regions and all income levels. Higher levels of use were observed in CTAs in the WHO South-East Asian and Eastern Mediterranean regions and among LMICs. Less use

was observed in the four low-income CTAs that reported data for 2022. Lower total AMU estimates in low-income countries have been reported previously *(26)*, indicating issues of access to essential antibiotics. Some variation in the extent of antibiotic use is expected among countries due to factors such as the burden of infectious diseases, the demographics and broader health system characteristics. Nevertheless, higher AMU in some CTAs compared to those with higher morbidity and mortality rates of infectious diseases suggests that overuse of antibiotics remains a problem.

Oral formulations are preferred in primary care and accounted for almost 95% of the reported volume in our analysis. As most non-severe infections can be safely and effectively treated with oral antibiotics, use of this route is encouraged. Its advantages include less risk, due to avoidance of use of vascular access lines (e.g. infections, thrombosis) and hospitalization. Countries with a high relative use of parenteral antibiotics (e.g. > 15–20%) should investigate the reasons, which could be due to data quality or overuse of parenteral antibiotics. The latter could be addressed by antibiotic stewardship interventions.

Analysis of the data by AWaRe category and the relation to the WHO EML provides a good indication of antibiotic use patterns among CTAs. The results suggest that, globally, countries should proportionally increase use of AWaRe Access antibiotics, decrease inappropriate use of Watch antibiotics, minimize use of Not classified or Not recommended antibiotics and ensure access to (and appropriate use of) Reserve antibiotics when necessary. Access antibiotics, recommended as first- or second-choice treatments for common infections because of their narrow spectrum, low cost, good safety profile and low potential for resistance, are expected to account for most antibiotic use. In this analysis, however, Access antibiotics accounted for only 53% of aggregated total use, indicating that more work is necessary to achieve the WHO AWaRe target of 70% global use. Only 19 CTAs, about one third of those that reported data, achieved ≥ 70% Access use. The data suggest that CTAs with higher overall antibiotic use used fewer Access products, implying that excess antibiotic use is often linked to greater use of Watch or Not classified or Not recommended antibiotics. The median use of Watch antibiotics was 33%, but it exceeded 45% in three fourths of the CTAs and was > 70% in 30% of the CTAs. Watch antibiotics are targets for antibiotic stewardship, particularly in CTAs in which their use exceeds that of Access antibiotics. Although use of Not classified or Not recommended antibiotics is probably underestimated because of inherent limitations of the ATC/DDD method (as many such antibiotics do not have an ATC code), their use in five CTAs exceeded 5%. The efficacy of these antibiotics, which are often fixed-dose combinations of broad-spectrum drugs, is usually not proven by evidence or recommended in high-quality guidelines. Investigation of the patterns of their use is crucial, as they could promote AMR. CTAs could consider removing them from national or local medicine lists, procurement lists, clinical guidelines and formularies.

The median use of Reserve antibiotics constituted < 0.2% of total use, with no use reported in nearly half of the low- and lower–middle-income CTAs. These antibiotics are intended as last-resort options for multidrug-resistant infections and are usually administered parenterally in hospitals; therefore, low use is expected. Essential Reserve antibiotics should, however, be available on the market in countries in which multidrug-resistant organisms are prevalent. A study of the national EMLs of 138 countries in 2021 reported few Reserve antibiotics on the EMLs of LMIC *(27)*.

While about 90% of antibiotic use is of WHO EML antibiotics, non-WHO EML antibiotics were more prevalent in the Watch category: 25% of CTAs reported 30–60% of the Watch volume from non-WHO EML sources. Two WHO EML antibiotics were not reported in the survey. There is already evidence of suboptimal concordance between national and WHO EMLs, especially for Watch and Reserve antibiotics *(27,28)*. This finding may prompt revisions of national EMLs and standard treatment guidelines according to the national burden of infectious diseases, the pattern of AMR and market regulation. The analysis may also indicate issues of access to antibiotics on the WHO EML for WHO and global partners.

In the reported data, 90% of the volume was concentrated in 11 ATC4 subgroups. Penicillins, macrolides and combinations of penicillins with beta-lactamase inhibitors were the most frequently used antibiotics globally, followed by fluoroquinolones and tetracyclines. While the two penicillin groups were the most frequently used antibiotic subgroups in 75% CTAs, macrolides and fluoroquinolones – subgroups composed of Watch antibiotics – were the most frequently used subgroups in 20% of CTAs, all of which are LMIC, indicating that antibiotic stewardship is necessary to address their inappropriate use. The Watch antibiotic azithromycin was the third most widely used and the most frequently used oral antibiotic in 8% of the CTAs. An increase in azithromycin use was reported in several countries in 2020, probably related to the coronavirus disease 2019 (COVID-19) pandemic, during which this antibiotic was often used inappropriately *(29)*. Extensive use of azithromycin warrants further investigation, as this substance is recommended in the AWaRe antibiotic book only as first-line therapy for specific infections, such as sexually transmitted infections, enteric fever, cholera and trachoma *(13)*. Some antibiotics were used relatively infrequently, although they are recommended as first-line treatments for common infections. For example, the oral Access antibiotic nitrofurantoin, which is recommended for lower urinary tract infections with excellent activity against some multidrug-resistant strains of *Escherichia coli*, unlike the other options listed on the WHO EML for this indication, appeared in the DU75 of only 25% of the CTAs. No use was reported by eight LMIC, which may be due to lack of availability or affordability of nitrofurantoin; this could result in prescription of less appropriate alternatives. Furthermore, nine CTAs reported no use of cefazolin, a parenteral antibiotic recommended in the AWaRe antibiotic book as the first choice for prophylaxis in most surgical procedures *(13)*.

5.2 Conclusion and way forward

Since the launch of the national AMU surveillance component of GLASS in 2020, participation has increased notably, and the global system now includes data from 67 CTAs, covering about one fifth of the global population. Despite this progress, global participation remains well below 50%, with the notable underrepresentation of non-European and non-high-income countries. Wider participation of Member States in GLASS-AMU is crucial for more comprehensive understanding of AMU patterns worldwide and for monitoring global progress towards better use of antimicrobials. Continued political commitment and financial, technical and human resources are necessary to scale up national surveillance, especially in LMIC, as are understanding and addressing the causes of non-engagement by countries. WHO is committed to consolidating and extending GLASS with support from Member States, WHO regional and country offices, regional networks, WHO collaborating centres and other international partners, to meet the 2024 UNGA target of all countries reporting high-quality surveillance data on AMU to GLASS by 2030 *(16)*, contributing together to improve patient care quality by combatting AMR.

National AMU data allow identification of areas for stewardship and tracking of progress to better access to and use of antibiotics. WHO is developing a document to assist countries in interpreting their AMU data to guide antimicrobial stewardship policies and interventions. WHO will also work with partners to define additional AMU indicators and targets, including overall national antibiotic use targets according to population health needs.

Analysis of the data for 2022 gives rise to four main conclusions that have implications for action.

- **First**, the analysis shows considerable variation in antibiotic use among regions and income levels for all the indicators analysed. The causes of the variation are incompletely understood. The quality of the data should be assessed to improve systems and to better explore the use of antibiotics in different settings as a basis for targeted interventions to improve antibiotic use. WHO will assist countries in developing sustainable systems for collecting granular, representative data at points of use for analysis of use in hospital and primary care and in public and private practice. A WHO Academy online course, “Antimicrobial use surveillance: competencies for policy and practice”, will provide comprehensive training in national surveillance structures, processes and tools. WHO will further support countries in mapping national medicine value chains and assessing different data sources.
- **Secondly**, the data point to a large relative use of Watch antibiotics, with a minority of countries meeting the target of 60% of national use being of Access antibiotics by 2023 and even fewer meeting the 70% target. Watch antibiotics contribute disproportionately to AMR, and global work to avoid unnecessary use of antibiotics and of Watch antibiotics in particular when Access antibiotics would suffice must continue. Several countries also reported high relative use of Not classified or Not recommended antibiotics, which could be reduced by national policies to improve AMU, such as limiting marketing authorization for Not recommended antibiotics.
- **Thirdly**, some LMIC reported very low or even no use of Reserve antibiotics. While last-resort Reserve antibiotics should be used judiciously, access to these antibiotics ensures that patients with infections due to multidrug-resistant priority pathogens such as carbapenem-resistant Enterobacterales can be treated appropriately *(30)*. WHO is working with partners such as the Global Antibiotic Research and Development Partnership to develop a framework for providing access to essential antibiotics for countries with limited resources *(31)*.
- **Fourthly**, some CTAs reported high relative use of parenteral formulations of antibiotics. This is a clear target for antimicrobial stewardship, as, for the vast majority of infections seen in primary care, oral antibiotics are equally effective, safer and cheaper.

While GLASS AMU addresses the human health sector, WHO is committed to the One Health approach to control AMR and will continue to work with its Quadripartite partners to ensure that comparable AMU indicators and targets are set in all sectors in the Quadripartite Global Integrated Surveillance System for AMR and AMU.

References

1. Naghavi M, Vollset SE, Ikuta KS, Swetschinski LR, Gray AP, Wool EE et al. Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. Lancet. 2024;404(10459):1199–226. https://doi.org/10.1016/S0140-6736(24)01867-1.
2. Klein EY, Van Boeckel TP, Martinez EM, Pant S, Gandra S, Levin SA et al. Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. Proc Natl Acad Sci U S A. 2018;115(15):E3463–70, https://doi.org/10.1073/pnas.1717295115.
3. Van Boeckel TP, Gandra S, Ashok A, Caudron Q, Grenfell BT, Levin SA et al. Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data. Lancet Infect Dis. 2014;14(8):742–50. https://doi.org/10.1016/S1473-3099(14)70780-7.
4. Klein EY, Impalli I, Poleon S, Denoel P, Cipriano M, Van Boeckel TP et al. Global trends in antibiotic consumption during 2016–2023 and future projections through 2030. Proc Natl Acad Sci U S A. 2024;121(49):e2411919121. https://doi.org/10.1073/pnas.2411919121.
5. Global action plan on antimicrobial resistance. Geneva: World Health Organization; 2015. https://iris.who.int/handle/10665/193736. License: CC BY-NC-SA 3.0 IGO.
6. WHO report on surveillance of antibiotic consumption: 2016–2018 early implementation. Geneva: World Health Organization; 2018. https://iris.who.int/handle/10665/277359. Licence: CC BY-NC-SA 3.0 IGO.
7. Global antimicrobial resistance and use surveillance system (GLASS) report: 2021. Geneva: World Health Organization; 2021. https://iris.who.int/handle/10665/341666. Licence: CC BY-NC-SA 3.0 IGO.
8. Global antimicrobial resistance and use surveillance system (GLASS) report: 2022. Geneva: World Health Organization; 2022. https://iris.who.int/handle/10665/364996. Licence: CC BY-NC-SA 3.0 IGO.
9. GLASS dashboard (online). World Health Organization (https://worldhealthorg.shinyapps.io/glass-dashboard/).
10. GLASS methodology for surveillance of national antimicrobial consumption. Geneva: World Health Organization; 2020. https://iris.who.int/handle/10665/336215. Licence: CC BY-NC-SA 3.0 IGO.
11. World Health Assembly. Thirteenth General Programme of Work, 2019–2023. Geneva: World Health Organization; 2018 (WHA71.1; https://iris.who.int/handle/10665/279451. Licence: CC BY-NC-SA 3.0 IGO).
12. Moja L, Zanichelli V, Mertz D, Gandra S, Cappello B, Cooke GS et al. WHO's essential medicines and AWaRe: recommendations on first- and second-choice antibiotics for empiric treatment of clinical infections. Clin Microbiol Infect. 2024;30 Suppl 2:S1–51. https://doi.org/10.1016/j.cmi.2024.02.003.
13. The WHO AWaRe (access, watch, reserve) antibiotic book. Geneva: World Health Organization; 2022. https://iris.who.int/handle/10665/365237. Licence: CC BY-NC-SA 3.0 IGO.
14. People-centred approach to addressing antimicrobial resistance in human health: WHO core package of interventions to support national action plans. Geneva: World Health Organization; 2023. https://iris.who.int/handle/10665/373458. Licence: CC BY-NC-SA 3.0 IGO.
15. Antimicrobial resistance: accelerating national and global responses: WHO strategic and operational priorities to address drug-resistant bacterial infections in the human health sector, 2025–2035. Report by the Director-General. Geneva: World Health Organization; 2024. https://apps.who.int/gb/ebwha/pdf_files/WHA77/A77_5-en.pdf.
16. Political declaration of the high-level meeting on antimicrobial resistance (online). New York: United Nations; 2024. https://www.un.org/pga/wp-content/uploads/sites/108/2024/09/FINAL-Text-AMR-to-PGA.pdf.
17. The selection and use of essential medicines 2023: web annex C: WHO AWaRe (access, watch, reserve) classification of antibiotics for evaluation and monitoring of use, 2023. Geneva: World Health Organization; 2023. https://iris.who.int/handle/10665/371093. Licence: CC BY-NC-SA 3.0 IGO.
18. ATC classification index with DDDs (online). Oslo: Norwegian Institute of Public Health; WHO Collaborating Centre for Drug Statistics Methodology; 2024. https://atcddd.fhi.no/atc_ddd_index/.

19. European Surveillance of Antimicrobial Consumption Network (ESAC-Net) (online). Stockholm: European Centre for Disease Prevention and Control. https://www.ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/esac-net.

20. WHO Regional Office for Europe Antimicrobial Medicines Consumption (AMC) Network: AMC data 2022. Copenhagen: World Health Organization Regional Office for Europe; 2024. https://iris.who.int/handle/10665/378747. Licence: CC BY-NC-SA 3.0 IGO.

21. Antimicrobial consumption in the WHO Western Pacific Region: early implementation of the Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS). Manila: WHO Regional Office for the Western Pacific; 2021. https://iris.who.int/handle/10665/351130. Licence: CC BY-NC-SA 3.0 IGO.

22. GLASS manual on the management of antimicrobial consumption data. Geneva: World Health Organization; 2020. https://iris.who.int/handle/10665/336216. Licence: CC BY-NC-SA 3.0 IGO.

23. The World Bank income group classification 2024. Washington DC: World Bank; 2024. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

24. Third Global High-level Ministerial Conference on Antimicrobial Resistance (AMR) in Muscat, Oman. The Muscat Ministerial Manifesto on Antimicrobial Resistance. Muscat, 2022. http://www.amrconference2022.om/MuscatManifesto.html.

25. Wells N, Nguyen VK, Harbarth S. Novel insights from financial analysis of the failure to commercialise plazomicin: Implications for the antibiotic investment ecosystem. Human Soc Sci Commun. 2024;11(1):941. https://doi.org/10.1057/s41599-024-03452-0.

26. Mendelson M, Lewnard JA, Sharland M, Cook A, Pouwels KB, Alimi Y et al. Ensuring progress on sustainable access to effective antibiotics at the 2024 UN General Assembly: a target-based approach. Lancet. 2024;403(10443):2551–64. https://doi.org/10.1016/S0140-6736(24)01019-5.

27. Adekoya I, Maraj D, Steiner L, Yaphe H, Moja L, Magrini N et al. Comparison of antibiotics included in national essential medicines lists of 138 countries using the WHO Access, Watch, Reserve (AWaRe) classification: a cross-sectional study. Lancet Infect Dis. 2021;21(10):1429–40. https://doi.org/10.1016/S1473-3099(20)30854-9.

28. Review of antibiotics in national medicines selection lists in eastern Europe and central Asia. Copenhagen: World Health Organization Regional Office for Europe; 2023. https://iris.who.int/handle/10665/365989. Licence: CC BY-NC-SA 3.0 IGO.

29. WHO Regional Office for Europe Antimicrobial Medicines Consumption (AMC) Network: AMC data 2020–2021. Copenhagen: World Health Organization Regional Office for Europe; 2023. https://iris.who.int/handle/10665/373913. Licence: CC BY-NC-SA 3.0 IGO.

30. WHO bacterial priority pathogens list, 2024: bacterial pathogens of public health importance, to guide research, development and strategies to prevent and control antimicrobial resistance. Geneva: World Health Organization; 2024. https://iris.who.int/handle/10665/376776. Licence: CC BY-NC-SA 3.0 IGO.

31. SECURE: Improving access to antibiotics (online). Geneva: World Health Organization; Global Antibiotic Research and Development Partnership (https://www.secureantibiotics.org/).

Annex 1. New terminology for antimicrobial use

WHO and other agencies, such as the European Centre for Disease Prevention and Control, have classically differentiated between AMC and AMU. Whereas AMC represents aggregated AMU on a large scale, AMU represents use patterns at patient level (Box A1.1.) *(1)*.

Box A1.1. Previous definitions

AMC was defined as an estimate "of aggregated data, mainly derived from import, sales or reimbursement databases", reflecting the total amount of antibiotics used nationally, regionally or at hospital level and usually quantified as DID or per patient-days or admissions to hospitals. Other numerators, such as the number of prescriptions or standard units, are also sometimes used for this purpose. These types of national data are collected and reported by GLASS *(1)*.

AMU was defined as "data on antibiotics taken by individual patients" with "data … collected at the patient level" allowing "a more comprehensive set of data to be gathered, such as information on indication, treatment schemes and patient characteristics" and therefore providing "additional information on prescribing practices […] for guiding antimicrobial stewardship activities *(1)*."

The classical distinction between AMC and AMU includes several concepts:

- data source (import, sales or reimbursement data versus patient charts);
- level of data aggregation (aggregated versus individual); and
- usefulness for antimicrobial stewardship (AMU data being more informative).

The concepts overlap significantly. The data source does not provide a clear distinction, as data on prescribing, dispensing or reimbursement may include individual-level information on indications or diagnoses, especially in settings with advanced electronic health records. The same applies to the extent of data aggregation, as any informative data on AMU must be aggregated at some level (such as on more than one patient), and patient-level data can be used to calculate metrics such as DID. While more detailed information about the clinical context in which an antimicrobial is used can usually be used to target antimicrobial stewardship, data aggregated at medicine level may still be useful for antimicrobial stewardship interventions and policies. (Otherwise, one may question why these data should be collected in the first place!)

There is a misconception that AMC represents only the "quantity" of antimicrobials used, while AMU measures the "quality" of their use. This distinction is misleading, as no single metric provides a complete picture of AMU in a particular setting. At global level, the only WHO quality indicator for antibiotic use endorsed by Member States is based on AMC data: the proportion of total use of Access group antibiotics, with the 70% global target.

Given these complexities and potential confusion between AMC and AMU among both experts and non-experts, we propose simplification of the terminology. We suggest use of the term "antimicrobial use" (AMU) for all relevant AMU monitoring data, "medicine-level" AMU data (m-AMU) for data that provide estimates of the volume of medicines used, with no additional context (previously referred to as AMC), and "clinical-level" AMU data (c-AMU) when the information on the antibiotic used is associated with clinical information (previously referred to as AMU).

Reference

1. GLASS methodology for surveillance of national antimicrobial consumption. Geneva: World Health Organization; 2020. https://iris.who.int/handle/10665/336215. Licence: CC BY-NC-SA 3.0 IGO.

Annex 2. Analysis and indicators used in the report

AMU volume was calculated in DDD and adjusted for population size by expressing it in DID to allow comparison of the density of use among CTAs. National populations were derived from the World Population Prospects 2024 for use as the denominator in total population as of 1 July 2024 *(1)*. When CTAs reported that their data covered a population that differed by more than 5% from that in the World Population Prospects, adjustments were made to align it with the population reported by the CTA. No adjustment was made to the numerator (volume of use) when the CTA reported that the data covered < 100% of the estimated use. Disclaimers indicate when the estimated overall coverage was < 90%.

The analysis was conducted with the 2023 versions of the ATC/DDD index *(2)*, the AWaRe classification and the WHO EML *(3)*. The World Bank classification of CTAs by income group in 2022 was used to classify CTAs by income level *(4)*.

The analysis first addressed the density of total use expressed in DID and then the pattern of antibiotic use by route of administration, WHO AWaRe classification and the WHO EML. The pattern of use of different antibiotics was then evaluated by antibiotic subgroup at ATC4 level, followed by a detailed analysis of oral and parenteral antibiotics, which together constitute 75% of oral and parenteral use of drugs (DU75). The indicators used in the report are summarized in Table A2.1.

Methodological consideration for applying the AWaRe classification

Only antibiotics were included in the analysis by AWaRe category. These include all those under "Antibacterial for systemic use – J01" (excluding methenamine, J01XX05), "intestinal antibiotics" in the A07AA class (excluding nystatin (A07AA02), natamycin (A07AA03) and amphotericin B (A07AA07)) and nitroimidazole derivatives in the P01AB class.

The 2023 AWaRe classification also includes rifampicin (J04AB02), rifamycin parenteral (J04AB03) and rifabutin (J04AB04), three antituberculosis medicines that are occasionally used to treat certain bacterial infections. These were excluded from the analysis because their primary use is for treating tuberculosis, and the GLASS method for national m-AMU surveillance does not differentiate antibiotics by the condition treated.

Access, Watch and Reserve antibiotics are classified according to the AWaRe classification, including the ATC code and, when relevant, the route of administration. The AWaRe classification does not yet systematically include Not recommended antibiotics in the ATC classification. Therefore, an ATC code cannot be used to categorize these antibiotics correctly. All substances not classified as Access, Watch or Reserve are therefore categorized as Not recommended or Not classified.

The Not recommended list includes certain beta-lactams and beta-lactamase inhibitor combinations, such as amoxicillin–sulbactam, with ATC codes in the Access category. These are retained, as the GLASS-AMU method does not allow further distinction according to the beta-lactamase inhibitor used.

Table A2.1. Indicators used in the report to describe AMU

Item	Indicators
Total antibiotic use	
To compare the density of medicine use among countries, the estimated volume of use should be adjusted by the population exposed to the estimated used volume. The national density of AMU is most frequently expressed as DID. WHO has not yet defined a target for this indicator.	**Total CTA antibiotic use:** number of DIDs used
Antibiotic use by route of administration	
In the ATC/DDD system, GLASS collects the route of administration as oral, parenteral, rectal or inhalation (as powder or solution). Oral administration is generally considered to be the most effective and safest method of administration of antimicrobials, as it is associated with fewer complications, lower health-care costs and earlier hospital discharge. Oral formulations are the preferred choice in primary care and can be considered a surrogate for community use, while parenteral use is used as surrogate for AMU in hospitals. WHO has not yet defined a target for this indicator, but a high proportion of parenteral use may indicate overuse of parenteral antibiotics.	**Proportion of antibiotic use by route of administration:** calculated as the proportion of the volume of antibiotics used by each route of administration (oral, parenteral, rectal, inhalation) over the total volume of antibiotics used in the CTA
Antibiotic use by AWaRe classification	
The WHO AWaRe classification is designed to guide local, national and global antibiotic stewardship. Antibiotics are classified into three groups – Access, Watch and Reserve – according to their impact on AMR to guide their appropriate use. This classification is also the basis for global targets for use, such as the GPW 2023 60% Access target and the UNGA 2030 70% Access target. WHO has not yet defined a target for this indicator when expressed in DID by AWaRe group.	**Global proportion of antibiotic use by AWaRe group:** proportion of the global volume of antibiotics used in each AWaRe group over the total global volume of antibiotics used. **National proportion of antibiotic use by AWaRe group:** proportion of the CTA volume of antibiotics used in each AWaRe group over the total volume of antibiotics used in the country **National density of antibiotic use by AWaRe group:** CTA density of use of each AWaRe group expressed as DID **Proportion of CTAs that achieve the GPW 2023 60% Access target:** proportion of CTAs in which use of Access antibiotics is ≥ 60% over the number of CTAs included in the analysis **Proportion of CTAs that achieve the UNGA 2030 70% Access target:** proportion of CTAs in which use of Access antibiotics is ≥ 70% over the number of CTAs included in the analysis
Antibiotic use according to the WHO EML	
The WHO EML guides countries in developing national EMLs. With introduction of the AWaRe classification in 2017, the WHO EML also facilitates revision of national lists by guiding prioritization to optimize antibiotic use. Use of most antibiotics that are not on the WHO EML should be minimized. WHO has not yet defined a target for this indicator.	**Proportion of WHO EML antibiotic substances on CTA lists:** proportion of CTAs that used more WHO EML antibiotics in each WHO AWaRe antibiotic group **Proportion of WHO EML antibiotic use in CTAs:** proportion of volume of WHO EML antibiotics over the total volume of antibiotics used in the CTA, for all antibiotics and in each WHO-AWaRe antibiotic group
Pattern of antibiotic use by antibiotic subgroup at ATC4 level	
In the ATC classification system, drugs are grouped according to their therapeutic use and chemical composition. For antibiotics, each ATC4 level specifies a different class or subclass of antibiotics according to their pharmacological properties, chemical structures or mechanisms of action. Analysis of the pattern of antibiotic use by subgroup at the AZC4 level shows the patterns of use of different antibiotics. WHO has not yet defined a target for this indicator.	**Proportion of antibiotic use in CTAs by ATC4 subgroup:** proportion of the volume of use of each AT4 antibiotic subgroup over the total volume of antibiotics used in the CTA

Table A2.1. (Continued) Indicators used in the report to describe AMU

Item	Indicators
Most frequently used oral and parenteral antibiotics	
In each CTA, relatively few antibiotics are used. Analysis of the patterns can help to identify the frequency of use of Watch, Not classified or Not recommended and Reserve antibiotics, which, if widely used, can be targets for stewardship. To identify the most frequently used oral and parenteral antibiotics, we used the DU75, which represents the antibiotics that cumulatively account for 75% of oral and of parenteral use. WHO has not yet defined a target for this indicator. In general, the most used antibiotics should mainly be from the Access group followed by the Watch group. Not recommended and Reserve antibiotics should not appear in the DU75.	**Proportion of oral antibiotic use by substance:** proportion of volume of use of each oral antibiotic in a CTA over total use of oral antibiotics. **Proportion of parenteral antibiotic use by substance:** proportion of volume of use of each parenteral antibiotic in a CTA over total use of parenteral antibiotics.

References

1. World Population Prospects 2024 (online). New York: United Nations, Department of Economic and Social Affairs Population Division; 2024. https://population.un.org/wpp/.
2. The selection and use of essential medicines 2023: web annex C: WHO AWaRe (access, watch, reserve) classification of antibiotics for evaluation and monitoring of use, 2023. Geneva: World Health Organization; 2023. https://iris.who.int/handle/10665/371093. Licence: CC BY-NC-SA 3.0 IGO.
3. Political declaration of the high-level meeting on antimicrobial resistance. New York: United Nations; 2024. https://www.un.org/pga/wp-content/uploads/sites/108/2024/09/FINAL-Text-AMR-to-PGA.pdf.
4. The World Bank income group classification 2024. Washington DC: World Bank; 2024. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

Annex 3. Considerations for data interpretation

The GLASS-AMU method provides a standard framework for global data collection, reporting and analysis, enabling comparisons among countries and over time. Several factors, however, may affect the accuracy and comparability of reported antibiotic use patterns. Some are related to application of the method in CTAs, while others are inherent to the method.

Variation in types of data: The different sources of AMU data each has advantages and limitations. For example, data on imports and local manufacturing may reflect production and procurement cycles rather than actual use, while data on dispensing and reimbursement, while providing more precise estimates of current use, may exclude over-the-counter sales and of antibiotics not covered by reimbursement.

Incomplete data coverage: Incomplete data can lead to underestimation of antibiotic use and a potentially biased pattern of use of different antibiotics. For example, use only of public sector data can skew use patterns towards a subset of antibiotics procured by the government, which are usually those listed on the national EML, and generally over-represent Access antibiotics. Use only of data on community use may result in underestimation of the use of parenteral formulations and fail to capture use of Reserve antibiotics.

Informal markets: The GLASS-AMU method relies solely on official data sources. In LMIC, sales of antibiotics on informal markets can significantly skew estimates of use. The impact depends on the scale of such markets (often unknown), the type (e.g. products entering or leaving the country illegally or reaching the population through parallel informal distribution and sales channels) and the data sources used. For instance, the presence of an informal market can lead to underestimation of use if the data sources are records of imports or local manufacture, whereas a large proportion of antibiotics enters the country illegally. Overestimation may occur if procured antibiotics are re-exported through illegal channels. Additionally, most falsified antibiotics circulate on the informal market.

ATC/DDD method: The ATC/DDD method, designed for use in adults, may result in underestimation of use in countries with large proportions of children and exclude antibiotics with no assigned ATC or DDD code. The limitation is particularly relevant for AWaRe Not classified combination products, which are common in some regions.

AWaRe classification: Discrepancies between the AWaRe classifications and GLASS methods and unclear guidance on applying AWaRe categorization to national AMU data may have limited standard use of the AWaRe categories to assess antibiotic use. In the AWaRe classification, Not recommended antibiotics are not systematically categorized in the ATC classification used by GLASS, potentially resulting in misclassification. For example, the list of Not recommended antibiotics includes some beta-lactams and beta-lactamase inhibitor combinations, such as amoxicillin–sulbactam, which are assigned to the Access category. Additionally, the AWaRe list includes several anti-TB medicines that are occasionally used to treat bacterial infections; however, the GLASS method for monitoring national AMU does not include differentiation by the condition treated. The criteria used to apply the AWaRe classification to the analysis reported are described in Annex 2.

Within-country variation: Numerous studies have documented wide variation in antibiotic use in countries (e.g. urban versus rural areas, different geographical regions). Only data aggregated at national level are reported to GLASS, so that within-country variation is not visible.

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