Final Report: Bangladesh

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CAPTURA
Capturing data on Antimicrobial resistance Patterns and Trends in Use in Regions of Asia

MOTT MACDONALD

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The CAPTURA consortium is led by the International Vaccine Institute (IVI), and includes as partners the Public Health Surveillance Group (PHSG), Harvard Medical School's Brigham & Women's Hospital (BWH), and Oxford University's Big Data Institute (BDI).

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Use of Document

This final report summarises CAPTURA engagements and activities conducted in Bangladesh. It is written to help inform planning future investments in combatting antimicrobial resistance (AMR) in the Asian Region and beyond. As such, it is aimed at any individual or organization interested and/or active in the field of AMR surveillance and research, in funding of AMR initiatives including policy and regulatory decision-making, and in infectious disease prevention and control programs in Bangladesh, the Asian region, and beyond. This covers academic, government, philanthropic, and private sectors, supranational organizations, and the general public.

The findings presented in this report have been generated based on data collected directly as part of the CAPTURA project as well as on previously generated original data. These data were shared under data sharing agreements between IEDCR of Bangladesh, individual public and private facilities, and the International Vaccine Institute (IVI). The use and/or reproduction of data or other report contents without agreement of IVI and the Government of Bangladesh (relating to original data contents) is not permitted.

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Executive Summary

As part of the large Fleming Fund (FF) portfolio of grants funded by the Government of the United Kingdom (UK) and established as a response to the global problem of antimicrobial resistance (AMR), in 2019 the CAPTURA project was awarded with the specific objective of expanding the volume of historical data on AMR, antimicrobial consumption (AMC), and antimicrobial use (AMU) in the human health care sector across 12 countries in South and Southeast Asia, including Bangladesh.

AMR context in Bangladesh

AMR is a growing threat for Bangladesh, for there are high levels of resistance to commonly used antimicrobials observed in the country. The AMR-National Action Plan (2017-2022) identified several challenges to address to achieve its objective to guide various sectors in ensuring a coherent, multi-sectoral approach towards combatting AMR. Although Bangladesh has a formal AMR surveillance system established, it remains in very early developmental stages. Complete financial and technical support is required until a sustainability plan is approved by the Government of Bangladesh. The country has also already put forth efforts into sharing AMR data generated from laboratories across the country at the global level. Progress is being made towards expansion of the AMR surveillance network and is currently coordinated by Institute of Epidemiology, Disease Control and Research (IEDCR) for the human health sector. Once AMR surveillance in the animal sectors is commenced, close collaboration to maximize the output between sectors is recommended.

Health care in Bangladesh is provided by both the Government of Bangladesh and the private sector. The Directorate General of Health Services (DGHS) and Directorate General of Drug Administration (DGDA) under the Ministry of Health and Family Welfare (MOHFW), along with multinational development agencies and external partners in the country, worked closely to upgrade the existing infrastructures and technologies to generate standardized quality data. Moreover, they provided trainings to prepare future leaders to champion the AMR containment efforts in the country.

The authority to regulate production, import, sales, and prescription of antimicrobials in the country lies with the DGDA. The government has already made effort to ban over the counter sales of antibiotics for use in animal feed and is conducting monitoring of import, production, and sales of antimicrobial agents in the country. Due to resource limitations and the challenge of monitoring a large number of unregistered facilities, however, these efforts are having limited effect. Consolidated data on antimicrobial production, procurement, and distribution is not available, and there is a need to systemically collect such prospective data. As Bangladesh has joined the Global Antimicrobial Resistance and Use Surveillance System – AMC (GLASS-AMC), establishing future data collection and following the GLASS methodology for surveillance will enable the country to better analyse, use, and share AMC data at both the local and global levels in the coming years.

To generate data on AMU, antimicrobial audits are currently being piloted with support from the FF Country Grant, and these are planned to be extended across the major hospitals in the country.

Continued collection of national AMR/C/U data will allow the country to further establish their national surveillance system as well as to implement evidence-based approaches for the treatment and management of infectious diseases, tracking of AMR trends, and formulation of AMR containment strategies.

CAPTURA experience

CAPTURA's early engagement with AMR stakeholders and subsequent effective coordination between the project team and Communicable Disease Control Program (CDC), IEDCR, DGDA, and MOHFW, led to expedited approval and work initiation. Although early progress was slowed by the COVID-19 pandemic, CAPTURA was able to successfully achieve its objectives of 1) identifying and assessing laboratories' existing microbiology capacity and collection and analysis of retrospective AMR data, and 2) providing WHONET trainings to technical laboratory staff (in both the human and animal health sectors). Further, a subset of AMU data was collected and analysed as part of a piloting exercise to understand the data quality in the country.

CAPTURA findings

CAPTURA activities in Bangladesh have enabled capacity building within data management and analysis for future AMR and AMU surveillance efforts. In this report, we present a summary of findings from the scoping and analytical work conducted by CAPTURA in collaboration with DGHS (CDC and IEDCR), DGDA, and MOHFW since 2019. The data content of this final report has been selected after discussion with the CAPTURA in-country team and AMR stakeholders from DGHS (CDC and IEDCR) and DGDA during CAPTURA's in-country workshop held in May 2022 in Dhaka, Bangladesh. Comprehensive analytical outputs and visualization tools will be shared with the National AMR program, DGHS (CDC and IEDCR), DGDA, and MOHFW of Bangladesh before the closure of the project.

The main utility of the retrospective data collected on AMR, and AMU through CAPTURA project in Bangladesh has been to identify the data sources and establish a preliminary data baseline. It is our hope it can be a useful contribution to planning future investments in combatting AMR in Bangladesh and the Asian region.

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Acronyms

AMC	Antimicrobial consumption
AMR	Antimicrobial resistance
AMU	Antimicrobial use
AST	Antimicrobial susceptibility testing
BDI	Big Data Institute
BWH	Brigham Women's Health
CA	Collaboration Agreement
CAPTURA	Capturing data on Antimicrobial resistance Patterns and Trends in Use in Regions of Asia
CDC	Communicable Disease Control
CIP	Country Implementation Plan
DDD	Defined Daily Doses
DGDA	Directorate General of Drug Administration
DTA	Data Transfer Agreement
ED	Emergency Department
EQAS	External Quality Assurance Services
FF	Fleming Fund
IEDCR	Institute of Epidemiology, Disease Control, and Research
IPD	Inpatient Department
IQC	Internal Quality Control
IVI	International Vaccine Institute
LIS	Laboratory Information System
OPD	Outpatient Department
MIC	Minimal Inhibitory Concentration
MOHFW	Ministry of Health and Family Welfare
MOU	Memorandum of Understanding
PHSG	Public Health Surveillance Group
PII	Personally Identifiable Information
QAAPT	Quick Analysis of Antimicrobial Patterns and Trends
(R, I, S)	Resistant, Intermediate, Susceptible (of infectious agents to antibiotics)
RLQA	Rapid Laboratory Quality Assessment
WHO	World Health Organization

SECTION

01

CAPTURA Overview

Introduction

The Capturing data on Antimicrobial resistance Patterns and Trends in Use in Regions of Asia (CAPTURA) consortium was awarded the Fleming Fund (FF) Regional Grants Round 1 for the South and Southeast Asian regions. These FF grants, funded by the Government of the United Kingdom (UK), were established as a response to the global problem of AMR, and the aims of Round 1 grants are to expand the volume of historical and current data on antimicrobial resistance (AMR), consumption (AMC) and use (AMU) data from the human health sector.

The CAPTURA project takes place in 12 countries- 6 in both South and Southeast Asia. The project includes collating retrospective AMR/C/U data, assessing the quality of datasets and laboratories where data were collected, and analysing data in order to make evidence-based recommendations for future policies and practices. Additionally, collaborative efforts with country stakeholders fostered capacity building opportunities and strengthened advocacy for improved data quality and submission to regional and/or national repositories. It is our hope that the CAPTURA project can assist in improving surveillance, containment, and awareness of AMR in local, regional, and global contexts.

The CAPTURA project was executed in several phases in Bangladesh (Figure 1).

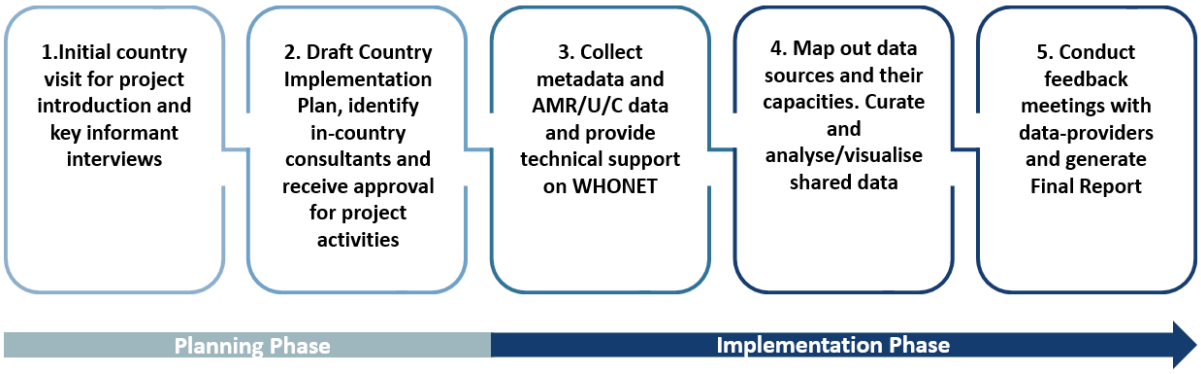


Figure 1. CAPTURA's scope of work in Bangladesh

AMR Context

AMR is a serious public health concern in Bangladesh. With a population of 166.3 million in 2021 according to United Nation's data,[1] the country has one of the highest population densities in the world at 1,265 people per square kilometer.[2] While the capital, Dhaka, has a large population and approximately 37.4% of people lived in urban areas in 2019, the majority of people still live in villages and rural areas.[3] Bangladesh has a decentralized healthcare system, with most health workers and health facilities concentrated in urban secondary and tertiary hospitals.[4] Many pharmacies and dispensaries are privately owned, which has resulted in easy access to over the counter drugs. Bangladesh has a robust domestic pharmaceutical industry, producing approximately 97% of the country's total medicinal needs.[5] Possible misuse of antibiotics in Bangladesh is attributed to a high proportion of medicine distribution points not being controlled by pharmacists (4 to 1) and a high percent usage of World Health Organization (WHO) "Watch" (54%) antibiotics.[6] In another study, the authors found that approximately half of antibiotics (50.9%) were purchased without a registered physician's prescription, and that a higher proportion of non-prescribed antibiotics dispensed were in the "Access" group (59.4%) followed by "Watch" (46.5%) and "Reserve" (43.8%) groups from the WHO Essential Medicines List Access.[7] Due to this structure, AMR and AMC surveillance is difficult to monitor.

Bangladesh's ministries and academic sector alike have taken an active role in addressing AMR. The CDC from the DGHS and the MOHFW led the creation and approval of the country's National Action Plan to address Antimicrobial Resistance Containment (ARC) in Bangladesh from 2017-2022. The Director of the CDC was selected as a national focal point to coordinate a national AMR containment program that has involved multi-sectoral stakeholders for a One Health (OH) approach. The National Strategy for AMR containment has eight main objectives:

1. To establish multi-sectoral approach for planning, coordination, and implementation of ARC activities;
2. To promote and ensure rational use of antimicrobial agents in human health, livestock, and fisheries sectors;
3. To promote and strengthen infection prevention and control measures to minimize the emergence and spread of AMR;
4. To promote and strength biosafety and biosecurity principles and practices and containment measures;
5. To review, update, and strengthen regulatory provisions;
6. To strengthen the surveillance system for AMR containment;
7. To promote operational research and education in the area of AMR;
8. To establish Advocacy, Communication, and Social Mobilization (ACSM) for ARC activities.[8]

Since the rollout of the National Action Plan in 2017, extensive country-led AMR work has taken place under the strong leadership of the CDC and IEDCR. In 2017, the IEDCR began conducting AMR surveillance with technical support from the US Centers for Disease Control and Prevention and WHO. In February 2020, the IEDCR was selected as the AMR

[1] Source: https://www.unfpa.org/data/world-population/BD, accessed 3/1/2022
[2] Source: https://www.worldometers.info/world-population/bangladesh-population/, accessed 3/1/2022
[3] Source: https://en.wikipedia.org/wiki/Demographics_of_Bangladesh#Urban_and_rural, accessed 3/1/2022
[4] Source: https://www.who.int/workforcealliance/countries/bgd/en/, accessed 3/1/2022
[5] Source: https://en.wikipedia.org/wiki/Pharmaceutical_industry_in_Bangladesh, accessed 3/1/2022
[6] E.S.F Orobu et al. *Mapping the Antimicrobial Supply Chain in Bangladesh: A sChoping-Review-Based Ecological Assessment Approach*. Global Health: Science and Practice September 2021, 9(3):532-547; https://doi.org/10.9745/GHSP-D-20-00502.
[7] M.A. Islam et al. Pattern of Antibiotic Dispensing at Pharmacies According to the WHO Access, Watch, Reserve (AWaRe) Classification in Bangladesh. *Antibiotics* 2022, *11*(2), 247; https://doi.org/10.3390/antibiotics11020247.
[8] National Action Plan: Antimicrobial Resistance Containment in Bangladesh, 2017-2022. Disease Control Unity, Communicable Disease Program, Directorate General of Health Services, Ministry of Health & Family Welfare. https://www.flemingfund.org/wp-content/uploads/d3379eafad36f597500cb07c21771ae3.pdf, accessed 3/1/2022.

Surveillance Coordination Center (AMRCC) and also as the National Reference Laboratory (NRL) for human health for national AMR surveillance.[9] The surveillance includes 9 sites across Bangladesh: Uttara Adhunik Medical College, Mymensingh Medical College, Rajshahi Medical College, Rangpur Medical College, the Bangladesh Institute of Tropical and Infectious Diseases (BITID), Dhaka Medical College, Khulna Medical College, Sylhet MAG Osmani Medical College, and Cox's Bazar Medical College and Hospital. Beginning in 2019, collected surveillance data has been submitted to GLASS. The IEDCR has made real-time graphical representation of the surveillance data available via a live dashboard (http://119.148.17.100:8080/amr/summary_graph.php).

The Directorate General of Drug Administration (DGDA) is the organization in Bangladesh responsible for ensuring the "quality, efficacy and safety of pharmaceutical products through the implementation of relevant legislation."[10] As such, the DGDA maintains records of AMU across the country, including "surveillance and pharmacovigilance activity."[11] The DGDA has also set up a program to improve the distribution of antimicrobials through the creation of Model Medicine Shops and Model Pharmacies across the country. With the support of the WHO country office in Bangladesh, academic studies have been conducted across the country to assess AMC;[12] publication of the data is pending after COVID-19-related delays.

In the time since CAPTURA implementation began in 2019, AMR initiatives have advanced significantly. The IEDCR and CDC demonstrated commitment to the surveillance program despite COVID-19 pandemic, and the DGDA explored implementation of AMC surveillance with the support of the FF Country Grant and fellowship activities. As the FF Country Grantee, DAI, has taken on a strong role coordinating with local stakeholders across the human sector and through a OH approach to strengthen sector-specific surveillance protocols and sampling strategies.[13]

[9] AMR Surveillance and Data Visualization, IEDCR. https://iedcr.gov.bd/pages/amr, accessed 3/2/2022

[10] About DGDA, Directorate Info. http://dgdagov.info/index.php/about-dgda/dgda-info, accessed 3/2/2022.

[11] About DGDA, Directorate Info. http://dgdagov.info/index.php/about-dgda/dgda-info, accessed 3/2/2022.

[12] WHO. Bangladesh embarks on monitoring Anti-Microbial Consumption. 28 December 2017 News release. https://www.who.int/bangladesh/news/detail/28-12-2017-bangladesh-embarks-on-monitoring-anti-microbial-consumption-(amc), accessed 3/2/2022.

[13] DAI: Bangladesh—Fleming Fund. https://www.dai.com/our-work/projects/bangladesh-fleming-fund, accessed 3/2/2022.

SECTION

02

CAPTURA Experience

Planning and Implementation

CAPTURA's engagement with Bangladesh's AMR stakeholders began when the CAPTURA consortium visited Dhaka, Bangladesh in November 2019 and introduced the CAPTURA project. The team had a series of meetings with IEDCR, the DGHS (CDC), the DGDA, WHO Country Office representatives, Uttara Adhunik and Dhaka Medical Colleges, icddr,b, the Line Director of Medical Education, staff from the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine, and Metabolic Disorders (BIRDEM) General Hospital, a senior scientist from department of Pharmacology at Bangabandhu Sheikh Mujib Medical University Hospital (BSMMU), and the Director of Hospitals and Clinics. The team gathered information on the current and historical AMR, AMU, and AMC efforts taking place in Bangladesh to better understand the infrastructure, priorities, and availability of data. During these meetings, the team also presented the goal of CAPTURA and explored areas for potential collaboration.

Key informant interviews were conducted with leading stakeholders to provide background information on what AMR, AMU, and AMC data were present or collected in the past years.

After the initial country visit, the CAPTURA team created a brief Country Implementation Plan (CIP) that outlined the proposed scope, objectives, and timeline of the work in Bangladesh. The CIP was presented to the DGHS (CDC and IEDCR) and DGDA for review and approval to conduct the proposed activities. CAPTURA was issued a letter of approval from the DGDA and authorization letter from CDC to conduct work with pharmacies and laboratories across Bangladesh. All the facilities that participated in data sharing each signed a Data Transfer Agreement (DTA) with the International Vaccine Institute (IVI) on behalf of CAPTURA.

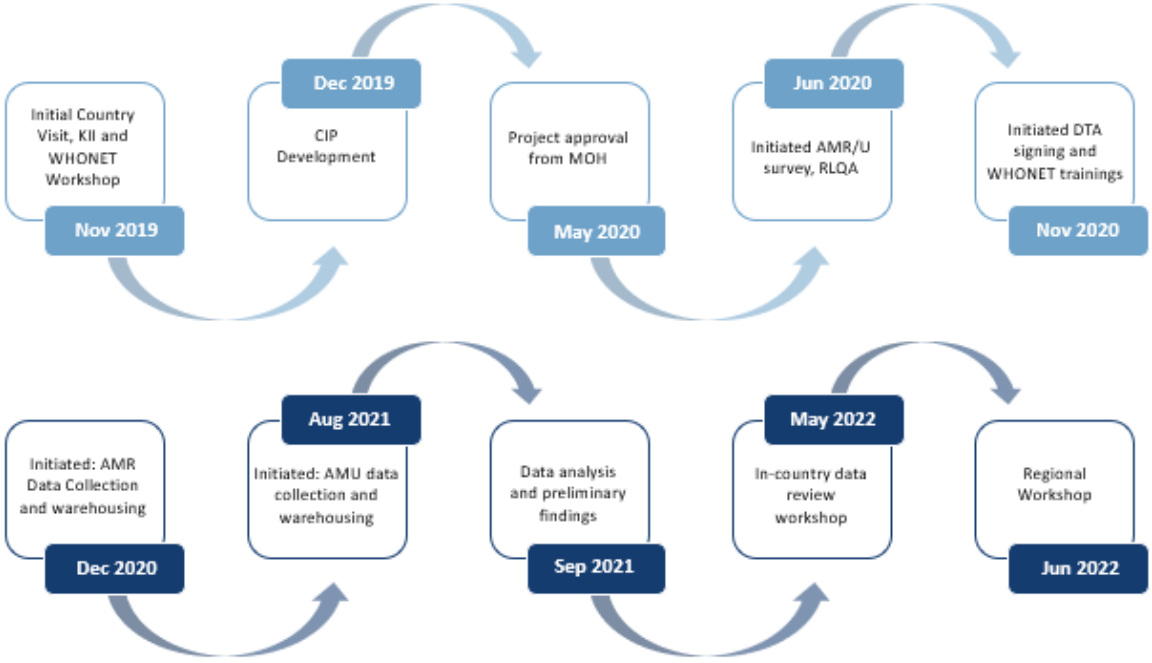


Figure 2. Timeline of activities in Bangladesh

Though in-country activities were unavoidably delayed due to the COVID-19 pandemic, implementation proceeded smoothly overall. An established in-country team carried out the core activities of the project and facilitated collaborations with stakeholders. Country stakeholders quickly reviewed approval requests, and the Bangladesh-based team quickly gathered metadata and AMR/U/C data and made travel arrangements that accommodated COVID lockdowns.

To track the progress of CAPTURA, the team conducted a virtual monitoring and midterm report at the end of 2020/early 2021 to calibrate progress. The team addressed incomplete collaboration agreements, data collection tools, and country priorities to create a micro plan and determine where to focus efforts during the final months.

A summary of the timeline for CAPTURA implementation is provided in Figure 2.

Capacity Building Activities

WHONET Training

WHONET is a free, Windows-based, multilingual database software developed for the management and analysis of microbiology laboratory data, with a special focus on the analysis of AST results. The software is primarily used to enhance the use of data for local needs: clinical decision support, AMU policy, infection control and outbreak detection, identifying laboratory test performance, and characterization of local microbial and resistance epidemiology. Additionally, it is used to promote local, national, regional, and global collaborations through the exchange of data and sharing of experiences.

CAPTURA supported several WHONET trainings (on-site and virtual) as a capacity building activity in Bangladesh. Laboratory staffs at IEDCR and the surveillance sites were trained on the use of WHONET. Subsequently, additional staff from laboratories were trained in data digitalization and processing prior to sharing the data with CAPTURA. Extensive WHONET training was provided to the in-country team by Dr. John Stelling, which enabled the staff at participating facilities to assist with data transfer and implementation of WHONET. Table 1 shows a list of WHONET training and/or support sessions held in Bangladesh.

Table 1. List of WHONET Training

Participating Facilities	Training date
IEDCR and surveillance sites	November 2019
IEDCR representatives	April 2020
Mymensingh Medical College, 12 participants	December 2020
Enam Medical College, 13 participants	December 2020
Jaharul Islam Medical College, 8 participants	January 2020
16 laboratory facilities in Dhaka, 45+ participants	January 2021
Cumilla Medical College, 5 participants	February 2021
Khulna Medical College Hospital, 7 participants	February 2021
Three laboratories combined training in Sylhet (Sylhet Medical College, Jalalabad Ragib Rabeya Medical College, North East Medical College), 12 participants	March 2021
Seven laboratories combined training in Chattogram (Bangladesh Institute of Tropical and Infectious Disease, Chattagram Ma-o-Shishu Hospital, Chevron Clinical Laboratory Pvt. Ltd., Chattagram Medical College and Hospital, Chattagram International Medical College, Epic Health Care, Metro Diagnostics Center), 17 participants	March 2021
Provided refresher training during AMR data collection	April – August 2021

SECTION

03

CAPTURA Findings

Results

In the following section, we present the findings from the work conducted by CAPTURA in collaboration with Bangladesh since 2019.

It is important to note that since most of the analysis and visualizations for the project were done using online visualization tools, some of the data presented in this report are displayed as screenshots from online dashboards and other similar platforms. As such, the legibility may be poor for some of the preliminary and "static" analytical outputs presented.

It is planned that all final analysis results and visualizations will be made available electronically to data owners and governments (where data owners are sharing at the national level). The final reports will contain selected graphics and data tables providing more general overviews but also will include links to relevant and more detailed electronic data visualizations.

Data Types

To identify the relevant data holding facilities and ensure evaluation of data quality, detailed assessments of facilities were conducted through facility questionnaires and visits before actual data sharing agreements were made and the source data collated. As a result, two levels of information are available and presented here:

1) CAPTURA metadata, which constitutes all of the information collected directly by, and as part of, the CAPTURA project from questionnaires and interviews;
2) CAPTURA AMR and AMU data, identified as retrospective source data generated in facilities between January 1, 2016, and December 31, 2020.

The overall approach to the selection of facilities and collation and analysis of different data sources is illustrated below (Figure 3). See the Appendix for more detailed information on the methods.

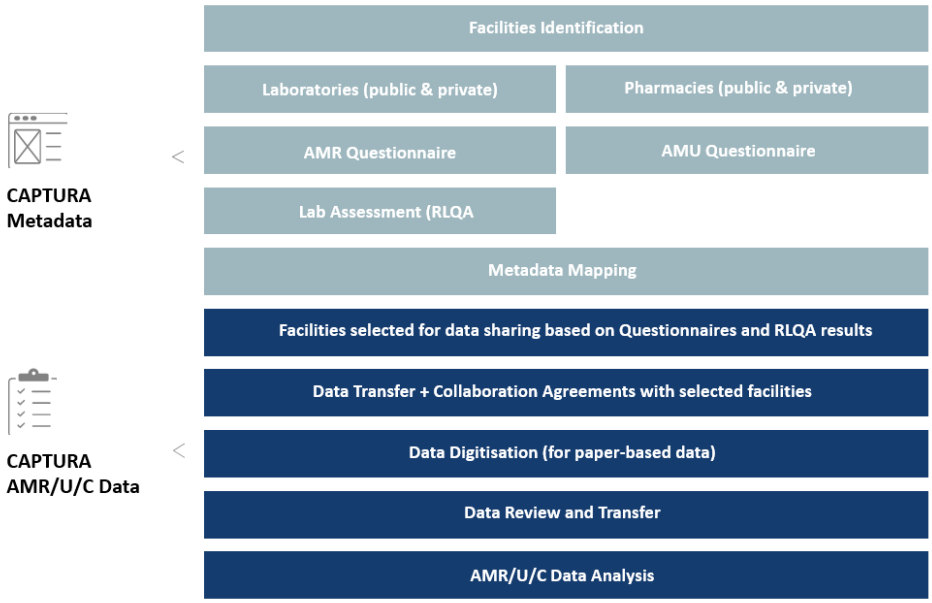


Figure 3. Approach to data identification and mapping

Facility Identification

In Bangladesh, many public and private facilities provide health care services to the population. Health services are regulated by the DGHS Hospitals and Clinics Section, and private facilities have a great degree of autonomy.

During the scoping phase, CAPTURA identified 90 public and private medical colleges, hospitals, and diagnostic facilities in the human health sector in Bangladesh thought to have existing capacity to conduct AST, as recommended by the CDC, IEDCR, and other stakeholders (Figure 4). Of those 90 laboratory facilities, 56 were targeted for inclusion in the project, as they reflected geographic diversity across the country, urban and rural diversity, included both private and public facilities, and were the 9 surveillance sited led by IEDCR. All 56 facilities were invited to an introductory meeting on CAPTURA and received ample follow-up from the team with instructions on how to complete the metadata questionnaires and lab assessment. Over the course of several months, 28 facilities fully completed the AMR Laboratory Questionnaire through in-person visits. The same facilities were approached for Rapid Laboratory Quality Assessment (RLQA) aimed at assessing retrospective laboratory capacity; the latter was used for grading AMR data quality for inclusion and analysis by CAPTURA. Out of the 56 facilities approached, 46 consented for RLQA; of these, only 45 were assessed by CAPTURA team (IEDCR was excluded from assessment). After the assessments were completed, 34 facilities signed a DTA with CAPTURA, and all 34 facilities successfully shared AMR data. This included an agreement with IEDCR for sharing the AMR surveillance data.

In Bangladesh, many of the pharmacies are privately owned and operated, even those connected with public hospital and health care facilities. It was thus challenging to link exact pharmacies to participating laboratory facilities. To identify relevant pharmacies associated with the participating facilities, the CAPTURA in-country team visited Model Pharmacies and Model Medicine Shops associated with or located near the same laboratories selected for RLQA visits. For this reason, although 45 pharmacies were originally targeted, the presence of several highly visited pharmacies surrounding the participating hospital/medical college-based laboratories led to the inclusion of 87 pharmacies that completed the AMU Questionnaire. Of those 87, only 5 pharmacies signed DTA with CAPTURA and shared AMU data. All included pharmacies were privately owned and operated.

An overview of all the facilities surveyed are provided in Tables 2 (Laboratories for AMR data availability) and 3 (Pharmacies for AMU data availability) in the following pages.

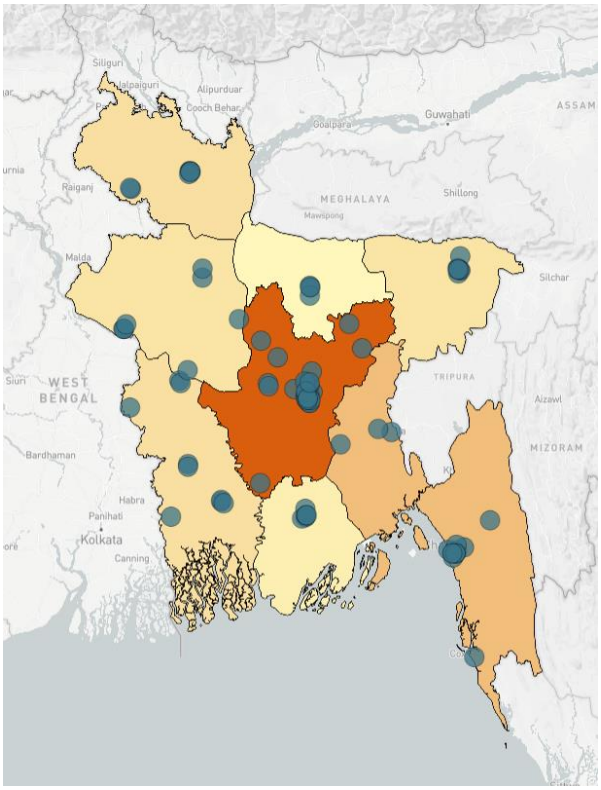


Figure 4. Map of facilities identified

AMR Metadata

Out of the targeted 56 facilities, 28 completed AMR questionnaires by August 2020. All 28 laboratories performed microbiology culture and conducted antimicrobial susceptibility testing (AST). Of the 28, 17 were hospital-based facilities serving as national referral/regional/district level service providers. Further breakdown showed that 13 laboratories were public facilities, 11 were privately owned, and the remaining 4 were managed by other sectors (nonprofit organizations/research units). All facilities conducted urine culture, while most processed other four different types of clinical specimens (blood, cerebrospinal fluids, soft tissue and bodily fluids, and stool) for bacteriological culture and susceptibility testing. Respiratory and genital samples were not

cultured by 7 facilities. Disk diffusion was the method used for AST by all facilities, and 4 also used automated systems for minimum inhibitory concentration (MIC) testing on a routine basis. More than half of the facilities conducted a large volume of AST (~ 1000 AST per month), while only half of the facilities maintained AST records for less than 1 year. Only 2 facilities maintained exclusive electronic records of AST, while 13 maintained both electronic and manual records. Twelve facilities kept only manual logbook-based records, while 1 did not maintain any records at all. Only 1 facility at the time of survey was using WHONET for data entry and management, 6 were using a custom Laboratory Information System (LIS), and the remaining laboratories used other software for recording AST data. Those using an electronic data recording system responded as having maintained up to 10 years of AST records. Eleven facilities also were sharing isolate level AMR data externally and analysing their own data either manually (16 facilities) or using EXCEL (4 facilities).

The RLQA was completed in by June 2021. In general, all the facilities were equipped and adequately staffed for performing basic microbiology assays, and a basic set of in-house prepared media was used by most of the laboratories. Particular gaps identified were regarding pathogen identification capacity, AST performance, and internal and external quality assurance (IQA and EQA) programs. Survey findings also revealed gaps in provision of refreshers training on blood culture. A common standard operating procedure (SOP) for microbiological processes for all laboratory facilities, as well as technical support for implementing the standard throughout the country, would help in generating quality data.

Table 2. Overview of facilities surveyed on data availability and capacity (AMR)

Name of Hospitals	AMR Questionnaire	Rapid Laboratory Quality Assessment
Bangladesh Institute of Tropical and Infectious Disease	✓	✓
North East Medical College Hospital	✓	✓
Sher E Bangla Medical College	✓	✓
Apollo Hospital (Evercare Hospital), Dhaka	✓	✓
Uttara Adhunik Medical College and Hospital	✓	✓
Bangladesh Specialized Hospital	✓	✓
Holy Family Red Crescent Medical College	✓	✓
Khulna Medical College	✓	✓
Sylhet MAG Medical College	✓	✓
Jalalabad Ragib-Rabeya Medical College	✓	✓
Rajshahi Medical College	✓	✓
Sir Salimullah Medical College	✓	✓
Child Health Research Foundation	✓	✓
Annex Diagnostic Centre	X	✓
Chattogram Maa-O-Shishu Hospital Medical College	✓	✓
Popular Diagnostic Ltd. Rajshahi	✓	✓
Japan Bangladesh Friendship Hospital	✓	✓
Cox's Bazar Medical College	✓	✓
Jahurul Islam Medical College	✓	✓
Epic Health Care	✓	✓
Square Hospital Dhaka	✓	✓
Mymenshingh Medical College	✓	✓
Enam Medical College Hospital	✓	✓
Rangpur Medical College	✓	✓
Chattogram International Medical College	✓	✓
Dhaka Medical College Hospital	X	✓
M Abdur Rahim Medical College and Hospital	X	✓
Saheed Ziaur Rahman Medical College (Bogura)	✓	✓
Metro Diagnostic Centre Ltd.	X	✓
Cumilla Medical College	X	✓
Chevron Clinical Laboratory Pvt. Ltd	X	✓
Swadesh Hospital	X	✓
Japan East West Medical College Hospital	X	✓
TMSS Medical College	X	✓
Chattogram Medical College and Hospital	✓	✓
Lab Aid Diagnostics Centre, Rangpur	X	✓
Popular Diagnostic Centre, Dhanmondi	✓	✓
Popular Diagnostic Centre, Shaymoli	X	✓
Lab Aid Specialized Hospital	X	✓
Ibn Sina Hospital Sylhet Limited	X	✓
Micropath Diagnostic Center	X	✓
Popular Diagnostic Center, Dinajpur	X	✓
Birdem Hospital	X	✓
South Apollo Medical College Hospital	X	✓
Bangabandhu Sheikh Mujib Medical University	X	✓
Ibn Sina Medical College Hospital	X	✓

AMU Metadata

All 87 surveyed pharmacies were dispensing antimicrobials, with 51 pharmacies maintaining records of the drugs dispensed. Similarly, almost all pharmacies responded that they require prescription for dispensing antimicrobial agents, but only 4 of them responded that they retain a copy of the prescription. Further survey responses indicated that most of the prescriptions did not contain diagnosis, and that the pharmacies' access to laboratory records was limited. Antimicrobial sales records were maintained by electronic, manual, or a combination of both formats by a majority of pharmacies. Three pharmacies reported having maintained more than 10 years of records in their database, though a majority of respondents reported maintaining records of up to 5 years.

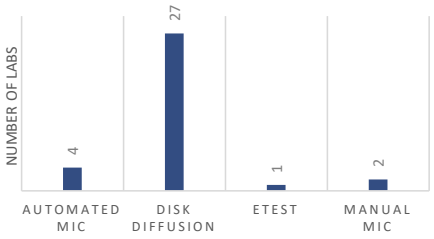
Nearly all pharmacies responded that they receive antimicrobial agents from private sector; as the surveyed pharmacies were all private, they have no access to antimicrobials supplied by the public sector. The private sector dominates the provision of basic care, laboratory, and ambulatory diagnostic services in Bangladesh. A WHO review of Bangladesh's health system estimates there are some 64,000 licensed pharmacies and 70,000 unlicensed drug stores selling all types of medicines, often without requiring prescriptions. Dispensing and stocking drugs using available guidelines is being followed by a majority of the pharmacies surveyed by CAPTURA, but periodic training on the guidelines are not being provided. Polypharmacy and dispensing by the prescriber are also common in the private sector, which constrains the rational use of medicines.

Table 3. Overview of facilities surveyed on data availability and capacity (AMU)

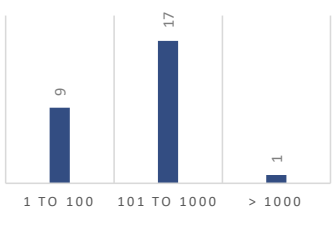
Name of Pharmacy Completing AMU Questionnaire			
Ibn Sina D-Lab Pharmacy	M/S Kolatoli Medical Hall	Jharana Medical Hall	Famous Pharmacy
Department of Pharmacy, Square Hospital	Maa Medical	Ishat Medical Hall	Noor Jahan Pharma
Popular Medical College Hospital Pharmacy	M/S Prescription	Mitali Pharmacy	Labaid Pharmacy
Evercare Hospital Pharmacy	M/S Haque Medico	Ferdousi Pharma	Ahmed Aoushadhalya
Jahurul Islam Medical College and Hospital Pharmacy	M/S Sharmika Medico	Sifat Pharmacy	Nahar Pharmacy
M/S Razu Pharmacy	Shahadat Pharma	Abdullah Pharmacy	Lopa Medicine Corner & Varieties Store
M/S Tasmia Pharmacy	Progoti Medical Hall (PHM)	Kakrail Pharma	Parul Medical Hall
Boyra Pharmacy	New Jibon Pharmacy & Surgicals	Lazz Pharma Bogura	Lazz Pharma Ltd.
Shrin Medical Hall	Shreshtha Medicine Corner	Rahman Medicine Corner	AKS Pharmacy
Moon Medicine	Safe Medicine Service (SMS)	Rony Pharmacy	Bangladesh Specialized Hospital Pharmacy
Mohasin Medical Hall	Life Pharmacy and Optics	Shetu Medical Hall	Onurag Pharma
Jahanara Pharmacy	Chattagram Maa-O-Sishu Hospital Pharmacy	Popular Medicine Corner	Bangladesh Pharma
Hawlader Medical Hall	Shibly Pharmacy	M/S Moontaha Pharmacy	Popular Medicine Corner
Shahreen Drugs	M/S Piya Medical Hall	Medical Pharma	Ibn Sina Pharmacy
Tivoli Pharmacy	M/S Medicine Square	Labaid Pharma	US Pharma and Health Store
VIP Drug House	Mainamati Pharmacy	Update Pharma	Japan Bangladesh Friendship Hospital Pharmacy
United Drug Store	Lazz Pharma Savar	New Dinajpur Pharmacy	Popular Medicine Corner
Suparna Drugland	Bonik Medicine Center	New Taher Medicine	Bismillah Pharmacy
Borno Pharmacy and Surgical	Mamun Medicine Center	Mouchak Medical Store	Holy Family Red Crescent Medical College Hospital Pharmacy
Popular Medicine Corner	Metbor Pharmacy	Central Medicine Store	Lazz Pharma Ltd.
Life Drugs	Raka Pharmacy	M/S Rokeya Pharmacy	Al-Shifa Medical Hall
Surma Medical Hall and Surgical	The B L Pharmacy		

AMR Metadata I

METHOD OF ANTIMICROBIAL SUSCEPTIBILITY TESTING (AST)



AST PER MONTH



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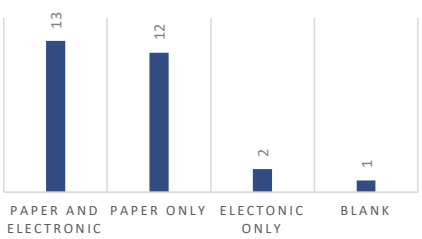
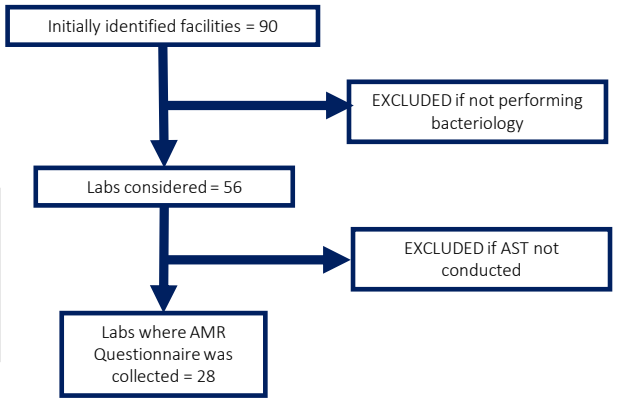
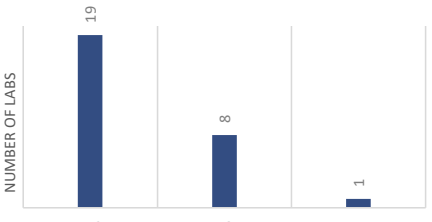
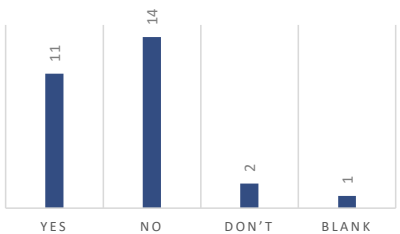




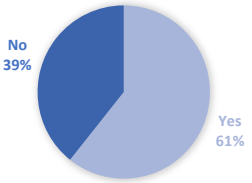
AMR ANALYSES CONDUCTED



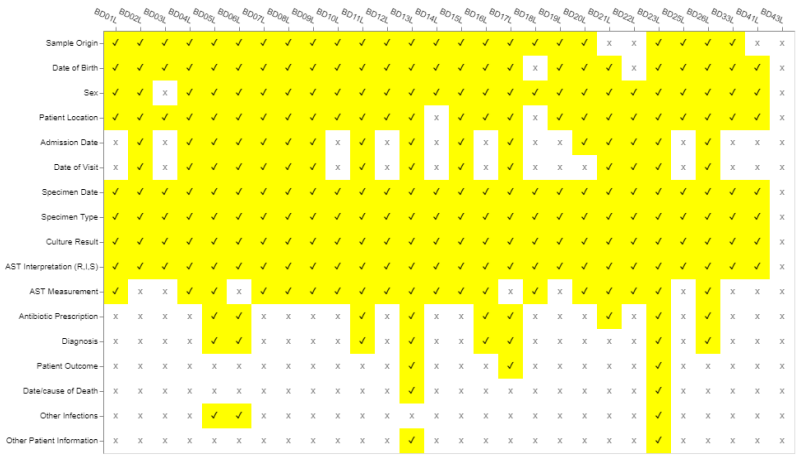
DATA SHARED EXTERNALLY



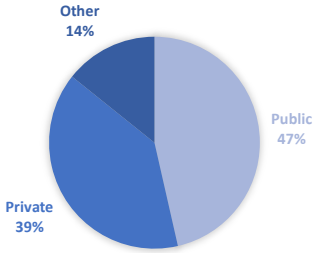
LOCATED IN HOSPITAL (N=28)

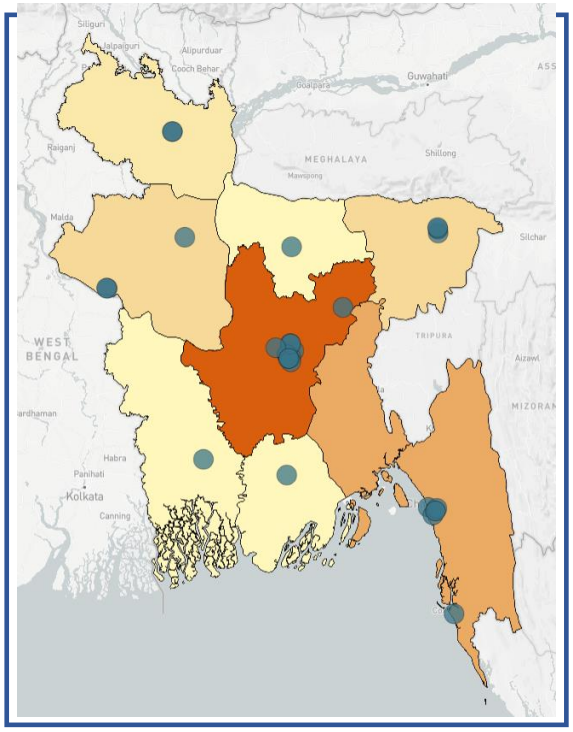


AVAILABLE AMR DATA VARIABLES IN LABORATORIES CONDUCTING AST (N=28)



AFFILIATION OF LABS (N=28)

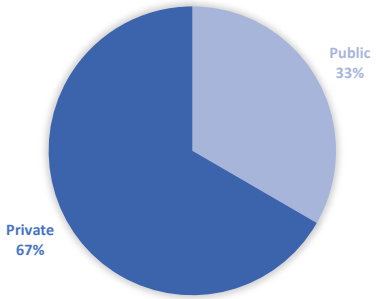




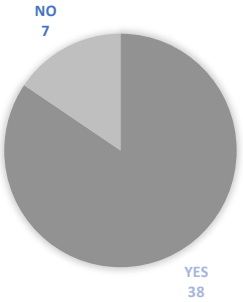
Indicated in circles are 28 facilities where AMR Questionnaires were collected.

AMR Metadata II

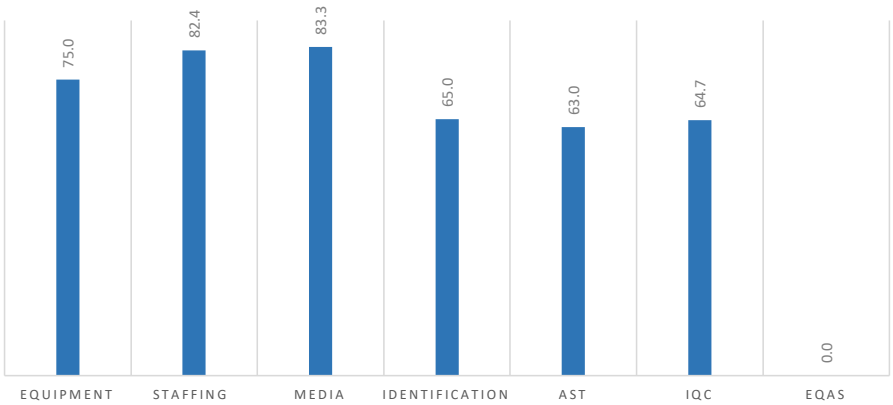
AFFILIATION OF LABS (N=45)



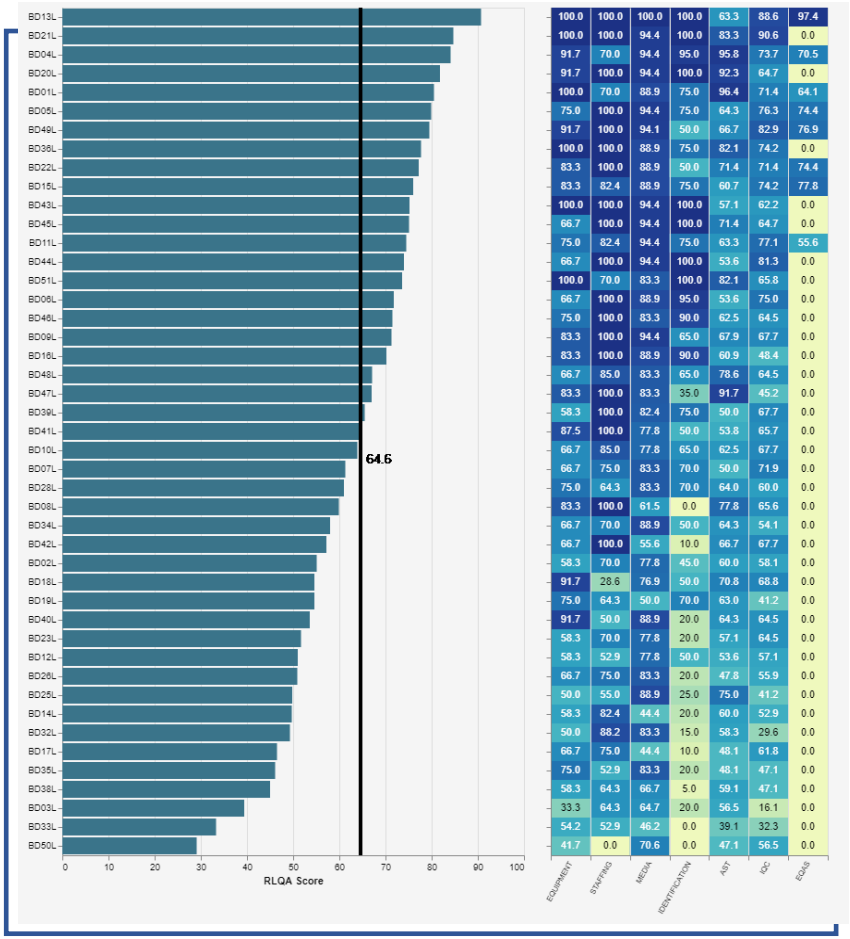
DATA SHARED WITH CAPTURA (N=45)



RLQA MEDIAN SCORES BY SECTION

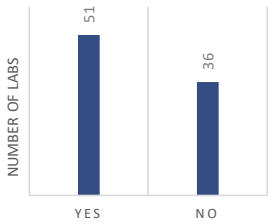


RAPID LABORATORY QUALITY ASSESSMENT SCORES (N=45)



AMU Metadata

DISPENSARY DATA RECORDED



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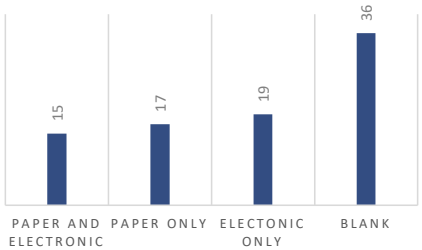

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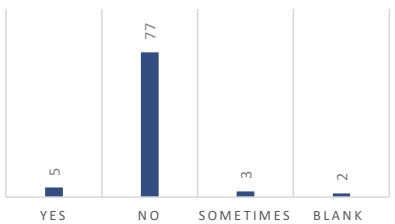
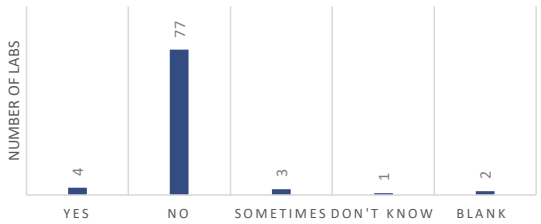
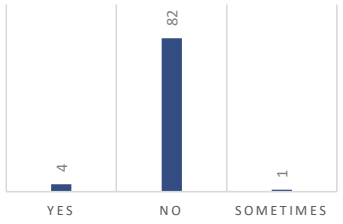


AFFILIATION OF PHARMACIES (N=87)

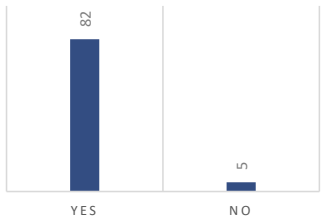
DIAGNOSIS ON PRESCRIPTION



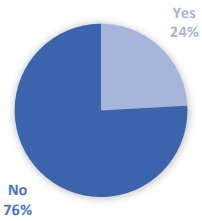
ACCESS TO LAB RESULTS



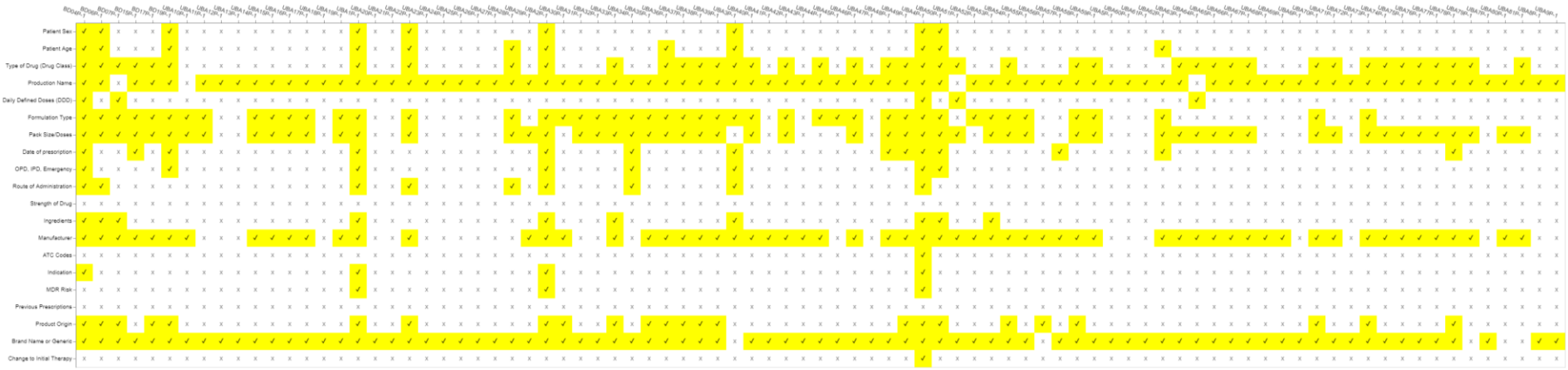
FOLLOW DISPENSING GUIDELINES



LOCATED IN HOSPITAL (N=87)



AVAILABLE AMU DATA VARIABLES IN PHARMACIES (N=87)



AMR data findings

Epidemiology

Bangladesh shared microbiological culture records from 34 laboratory facilities; among these, 1 facility (IEDCR), shared a collated dataset obtained from 9 sentinel sites across the country as part of the AMR surveillance network. CAPTURA considered this dataset a single unit and analysed it accordingly. A consolidated WHONET report (Epidemiology and Quality Report) after combining all 34 datasets was prepared to generate this country report, and to report the findings accordingly.

There were 1,037,002 culture records from 2016 to 2020, of which 299,786 (28.90%) records reported bacterial growth and their AST results (in-case of clinically significant finding). A total of 736,077 records were reported as no growth or negative, while 1,139 records were missing culture results. Among the records with bacterial growth, 23,888 records reported no significant findings or did not yield a pathogen (no significant growth, normal flora, mixed bacterial species, no pathogens found etc.). A majority of the records received were generated during 2017-2020, with a stark drop in the number of records during the early months of 2020, likely due to the COVID pandemic. Of the total records (both growth and no growth findings), urine (59.7%) comprised the highest number of samples tested, followed by blood (20.80%), soft tissue and bodily fluids (10.30%), and respiratory specimens (5.2%). This reflects the normal observance in any diagnostic lab where approximately half of tested samples are urine. A descriptive data summary is presented on pages 29-32, including details on the number of samples processed, the number of isolates, and patient and sample demographics.

Organism statistics**:**

The most common bacteria isolated in the dataset obtained was *Escherichia coli* (nearly 34.71% of positive records with pathogen identified) followed by *Klebsiella* sp., *Pseudomonas* sp., *Staphylococcus aureus,* and *Enterococcus* sp. (approximately 14.51%, 10.14%, 8.83%, and 6.86%, respectively). A relatively high number of *Salmonella* Typhi (n=9411; approx. 3.41% of total positive report) was observed during analysis, indicating a high burden of the disease in Bangladesh. Similarly, infrequent isolation of important public health priority pathogens, such as *Neisseria gonorrhoeae, Neisseria meningitidis*, *Vibrio cholerae*, *Streptococcus agalactiae*, *Bacillus cereus* etc., warrants close monitoring to prevent periodic outbreaks and development of resistance.

The positivity rate was highest among urine samples (51.4%), which corresponds proportionally to the number of urine samples tested. Even though blood culture was performed in higher frequency compared to soft tissue and bodily fluid, the bacterial isolation rate from blood (10.8%) was relatively lower than the latter (24.0%). In general, the blood culture positivity rate, even among patients clinically suspected of having sepsis, would be low, and even lower when on antibiotic therapy. The blood culture positivity rate in the Bangladesh dataset was within normal range. However, it is important that these observations are reported and interpreted by an expert and that high quality standards of the data generated are maintained for further use of these data as evidence for policy making. An absence of standard protocol for reporting a pathogen may lead to over-reporting or false positive results from bacterial contaminants/normal flora, and these factors have a direct effect on patient management as well as the development of guidelines and policies.

Given that urine samples were the most frequently tested specimen and had the highest culture positivity rate, *Escherichia coli* (54.61% of total positive urine samples) was found to be the most frequently isolated organism. This ultimately adds to the overall positivity and also makes this organism the most frequently isolated organism in aggregated analysis, which is a common finding in any diagnostic laboratory. *Klebsiella* spp., *Enterococcus, Pseudomonas* spp., and *Staphylococcus aureus* constituted other organisms among the top five pathogens isolated from urine samples. Further, *Salmonella* Typhi, coagulase-negative *Staphylococci*, *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas* spp., were the top 5 isolates from blood cultures. It is worth mentioning that coagulase-negative *Staphylococci* which is a part of normal skin flora, was reported frequently in blood culture as positive finding. As mentioned above, it is essential for the lab/s to ensure quality assured results to consider these as true pathogens, rather than contaminants. Also, known diarrheal agents like *Escherichia coli, Shigella* spp., and *Salmonella* spp. were isolated from stool cultures. The isolation of *Salmonella* spp., including Typhi and Paratyphi from blood and stool, highlights the fact that typhoid and para-typhoid fever remain endemic in the country and require targeted intervention for

elimination, including WASH and vaccination. Importantly, identifying and reporting *Escherichia coli* as the most frequently isolated intestinal pathogen from stool warrants further confirmatory tests; this is because *Escherichia coli* also exists as normal gut flora, and only certain strains are diarrheagenic. Reporting this pathogen without confirmatory testing/evidence for diarrheagenic *Escherichia coli* could therefore lead to inappropriate treatment protocols being used for patient management, including the misuse of antimicrobials; this would further contribute to the development of AMR.

From 2017 to 2019, there was an increase in the isolation of *Acinetobacter, Pseudomonas,* and *Enterococcus*. As the dataset shared with CAPTURA was retrospectively collated and not complete in terms of essential variables, we were not able to categorize the isolates as community acquired or hospital associated. It was thus not possible to comment on the increase in terms of where these organisms were isolated and their isolation rate. However, a gradual increase in testing over the period was observed, which also may be a reason for the increase in the number seen. Nevertheless, a true increase in frequency of pathogens associated with hospital associated infections requires close monitoring, as these organisms are mostly associated with high levels of AMR, including multidrug resistance (MDR).

Antimicrobial results:
Detailed analyses of resistance profiles on the isolated pathogens, including Gram-positive and Gram-negative antibiograms, have been generated and will be shared with the laboratories generating the data. In general, high levels of resistance were observed in the pathogens associated with hospital acquired infections, and *Salmonella* Typhi resistant to aminoglycosides and decreased susceptibility to Ciprofloxacin was also observed. Further, the Bangladesh data shows that there have not been any major changes in antimicrobial susceptibility trends in the country over the last 4 years. Resistance rates were also determined for the WHO Global priority list of resistant bacteria. A number of critical priority bacteria, including carbapenem resistant *Acinetobacter* spp. (56%) and ceftriaxone/cefotaxime resistant *Escherichia coli* (up to 61%) were observed; these require attention and close monitoring for containment. Similarly, isolation of high priority pathogens like methicillin resistant *Staphylococcus aureus* (MRSA), fluoroquinolone resistant *Neisseria gonorrhoeae,* and *Salmonella* spp. (ciprofloxacin resistant) is also an area where close monitoring and intervention is required. Observance of high levels of resistance in WHO GLASS pathogens, particularly the SDG indicator for blood isolates of MRSA (48%), is alarming. Most importantly, authorities should ensure a mechanism to verify and confirm frequent isolation of vancomycin resistant *Staphylococcus aureus* (VRSA; ~5%) and vancomycin intermediate *Staphylococcus aureus* (VISA; ~2%) strains. If these percentages are true, this is a matter of public health concern for Bangladesh. It must be noted, though, that these findings are questionable, as VRSA is an uncommon finding. It may indicate quality issues at the laboratories, which also needs immediate attention.

MDR, extensively drug resistant (XDR), and pan drug resistant (PDR) profiles need to be followed closely over time for outbreak detection, development of treatment guidelines, characterization of resistance mechanisms, and/or recognition of possible errors in laboratory testing. Confirmation of XDR/PDR requires testing using all classes of antimicrobials, which is not commonly practiced in diagnostic labs. Thus, WHONET identifies possible XDR/PDR based on the antimicrobials tested. Table 4 below lists the frequency of isolation of MDR and possible XDR and PDR in the received dataset.

While resistance rates and profiles are valuable in monitoring resistance trends over time and in developing treatment guidelines, policymakers must be very aware of laboratory testing quality and the different types of bias due to patient presentation, sampling practices, and laboratory testing practices.

Table 4. Summary of MDR, XDR, PDR

Organism	Number of isolates	MDR	Possible XDR	Possible PDR
Staphylococcus aureus	24,659	11,377 (46%)	5,156 (21%)	1,219 (5%)
Enterococcus faecalis	5,068	581 (11%)	576 (11%)	18 (0%)
Enterococcus faecium	2,564	570 (22%)	566 (22%)	9 (0%)
Escherichia coli	95,775	57,237 (60%)	27,120 (28%)	1,775 (2%)
Klebsiella pneumoniae	13,381	8,116 (61%)	4,904 (37%)	886 (7%)
Pseudomonas aeruginosa	3,863	1,945 (50%)	1,756 (45%)	652 (17%)
Acinetobacter sp.	9,844	7,497 (76%)	6,203 (63%)	725 (7%)

Test practices and quality report
This section addresses the issue of "quality" from several perspectives. The analyses include a number of indicator metrics used to identify priority areas for improvement, monitor improvement over time, and compare results from different laboratories.

- Data entry and data management: Completeness and accuracy of data entry, antibiotic configuration, and use of recommended WHONET codes
- Laboratory results: Organism identification, antimicrobial susceptibility test practices, and quality control results

Data entry:
Data completeness of the core data variables available was excellent (97%). Though the dataset was complete, a small deficiency was observed in recording the location of samples and the sex of the patients from whom samples were collected. Identifying patients' sex is valuable for descriptive analysis of epidemiology of the samples being processed over time.

It is recommended to use quality control strains at regular intervals to ensure the reliability of test results, as maintaining such records is part of good documentation practice. None of the data files analysed contained data related to testing of quality control strains.

Organism identifications**:**
Other than *Escherichia coli* and *Staphylococcus aureus*, the laboratories in Bangladesh were able to identify up to 30% of isolated organisms to species level; *Enterococcus* (41%), *Klebsiella* (35%), and *Pseudomonas* (15%) were the most reported up to species level. Several fastidious organisms such as *Streptococcus pneumoniae, Neisseria gonorrhoeae, Hemophilus influenzae,* etc., were also isolated in some of the laboratories. This is an indicator of the laboratory's capacity to receive, process, isolate, and identify samples with special growth characteristics.

AST practices:
All laboratories that shared data with CAPTURA were performing disk diffusion testing for AST and reporting results following Clinical Laboratory Standard Institute (CLSI) guidelines. A fewer number of MIC records tested following EUCAST guidelines for colistin was also shared. Due to a limited number of records, no further analyses were conducted for MIC findings.

As antimicrobials were not consistently tested, it was not possible to generate results for regularly tested core antimicrobials from the dataset. We recommend adoption of a set of standard antimicrobials to be promoted within and among laboratories both to support routine clinical decision support needs and to improve comparability of findings over time and between facilities.

There were results for several antimicrobials for which validated CLSI breakpoints do not exist. This may be either because the lab is testing incorrect antimicrobials, or there is a mistake in laboratory configuration of WHONET. In both circumstances, corrective action is indicated. If there was a mistake in the WHONET or BacLink configuration, this should be corrected. If the laboratory was performing incorrect testing, then education and review of purchasing and test practices would be indicated.

Test interpretations (RIS) were recorded, but no labs recorded inhibition zone diameters. We recommend to in the future record disk diffusion zone diameters in order to 1) improve the assessment of data quality, 2) improve the recognition and tracking of microbial sub-populations, and 3) permit data reanalysis if breakpoints change.

Isolate alerts:
WHONET generated several isolate-level alerts. From a public health perspective, some of the more important ones included high-priority important species: *Neisseria gonorrhoeae*, *Neisseria meningitidis*, and *Salmonella* Typhi. From a quality perspective, alerts to facilitate the recognition of possible deficiencies in test performance were generated. Isolation of colistin or polymyxin non-susceptible *Acinetobacter, Citrobacter, Escherichia coli, Klebsiella,* etc. needs further confirmation. This is because quality control alerts do not necessarily indicate that a result is incorrect but repeat testing and confirmation will validate the results.

In summary, key issues in susceptibility test practices were noted, especially 1) the testing of antimicrobials for which there are no validated CLSI interpretative criteria; and 2) inconsistency in antimicrobial susceptibility test practices (e.g., only 3 antimicrobials were tested more than 80% of the time for *Staphylococcus aureus,* while only 5 antimicrobials were tested against 40-60% of the isolates). There were no disk diffusion zone diameters records, which is typical of most databases. As mentioned, recording zone diameters in the future would offer several

benefits for determining reliability of clinical reports, quality assessment, and epidemiological monitoring.

Notes on data cleaning:

Several stages of data cleaning were conducted as CAPTURA was tasked to identify and collate retrospective data from varying facilities across the country. During data collection, the in-country team checked each dataset to understand the data quality and collection mechanism. A "readme" file was filled out noting the coverage and format of data. Basic cleaning (e.g., removal of redundant entries) was also performed prior to uploading on the CAPTURA warehouse. Following the upload, data was reviewed and cleaned in preparation for analyses. This task (e.g., removing outliers, identifying entry errors) was performed by the in-country coordinator under the guidance of Dr. John Stelling. The quality functions of the WHONET software were primarily used to clean data. However, as each dataset had been collected following different data management systems, a tailored approach for data curation was found necessary. Beyond the initial cleaning via WHONET, each dataset required closer examination and hands-on curation, thus another layer of curation was conducted by the CAPTURA Data Team. In this process, using the SQLite Database Browser software, the team found additional outliers, incorrect organisms, null specimen dates, incorrect AST results by antibiotics, and unified RIS values. Following this additional curation, the data team was then able to combine each dataset for country-level analysis. Cleaned datasets were combined using the WHONET data combination and encryption tool. Furthermore, the Quick Analysis of Antimicrobial Patterns and Trends (QAAPT) application was used to combine heterogeneous specimen dates and NULL data for different types of bacteria, including *Escherichia coli, Klebsiella, Enterococcus, Acinetobacter, Staphylococcus, Pseudomonas, Porteous, Candida,* and *Streptococcus*. Major specimens including Blood, Genital, Respiratory, Soft Tissue and Bodily Fluids, Urine, Stool, Others, and Unknown were also combined and categorized. As the nature of the CAPTURA project was to identify and collate retrospective data, understanding how data had been collected in the past was an inevitable challenge. The project was subject to an iterative process of checking with facilities for their insights and then curating data best to knowledge. Similarly, some level of estimation to analyse and interpret data was required, requiring constant confirmation from microbiologists and the existing literature.

AMU data findings

Monitoring AMC within a country, region, or facility is an important component of any National Action Plan to combat AMR. To understand how antimicrobials are prescribed and dispensed at health facilities, it is important to conduct surveillance for AMU. Although often used interchangeably with AMC, the two are in fact quite different:

AMC can be understood as aggregated data of sold, dispensed, or imported antimicrobials. This is captured by way of national-level or hospital-level estimates of the quantities of antimicrobials. WHO's GLASS platform aims at capturing AMC data across countries. In the case of hospitals, AMC data can be derived from dispensing records to patients. Several countries worldwide actually derive AMC data for GLASS from patient or reimbursement records.

AMU refers to data on the antimicrobials taken by individual patients (humans or animals). Data are collected at the patient level and include information on indication, treatment regimen, route of administration, and patient characteristics. In general, the collection of data on AMU requires more resources. Typically, AMU data are often collected using a Point Prevalence Survey (PPS). Globally, there are two PPS protocols in common use: the Global PPS, and the WHO methodology.
Adherence to a surveillance protocol is important given that AMU surveillance is focused on individual patient records and provides information on prescribing practices, which are important for guiding antimicrobial stewardship activities.

Given the scope of the CAPTURA project with its objective to collect and analyse datasets retrospectively, it was not possible to apply the commonly used AMU protocols. Rather, CAPTURA's approach to curation and analysis was guided by the protocols in creating a CAPTURA AMU template, through which the existing raw datasets would run.

Given the retrospective nature of the data, it is worth noting that there are several limitations to the data

curation and analysis process. Key contextual variables were either not recorded/available or not always collected in a coherent manner. Validation of the completeness and correctness of existing data entries was also not possible.

CAPTURA's AMU analysis is therefore exploratory in nature, and CAPTURA stresses that only prospective AMU surveillance, with the application of a rigorous methodology, can serve as a baseline for stewardship measures.

Data Overview and Key findings

The AMU findings in this report were generated from the data collated by CAPTURA from private hospital pharmacies in Dhaka, Bangladesh.

Data in electronic form were received from private pharmacies associated with tertiary care hospitals and contained antimicrobial sales for inpatients for the years of 2016 to 2021. CAPTURA used the Anatomical Therapeutic Chemical (ATC) classification system[1] to classify antimicrobial substances. Data were shared by the following 5 pharmacies listed below:

- Evercare Hospital Pharmacy
- Labaid Hospital Pharmacy
- Popular Medical College Hospital Pharmacy
- Square Hospital Pharmacy
- Ibn Sina Hospital Pharmacy

The raw dataset, comprised of all 5 hospital pharmacies, contained 7,427,740 rows of data which, after initial curation, resulted into 966,019 observations with information on the pharmaceutical items and patient demographics (age and gender). An overview of the data shared is shown in Table 5.

Table 5. Overview of data shared

Facility	Years of data	Observations	Number of patients (in dataset)	Admission numbers (from hospital)	Department
A	2017-2020	200186	139 694	NA	IPD
B	2016-2021	306470	53235	Y	Mixed
C	2018-2021	26449	4403	Y	IPD
D	2017-2021	72992	20241	Y	IPD
E	2018-2020	359922	41948	Y	IPD

After a standard dataset exploration, cleaning was performed to recode any observations or variables containing typos and to regroup certain observations and variables as deemed necessary for performing analysis and visualizations. Missing values were also removed.

The patient level data were limited to only age and gender as the dataset lacked diagnosis, indication, or ward information, making it difficult to perform detailed analysis. However, descriptive analyses of age and gender, distribution visualizations, and an analysis similar to Hospital-AMC were performed, considering the data's nature as facility-level sales data.

A few key findings from the analysis included significant fluctuations in total consumption per facility, measured as defined daily daily doses (DDD), of 200 ~ DDD 3000 per 100 admissions. Consumption patterns across the 5 facilities varied, with most of them having fluctuating numbers over the years. Two of the facilities saw a rise in consumption in 2020 and 2021, whereas another observed a slight decrease in 2020. It is difficult to discern the reasoning behind these patterns considering their unique practices and also the data limitations observed during curation and analyses. Use of beta-lactams including penicillin was highest in all the facilities over the years, while quinolones were the second most commonly used. Macrolides and aminoglycosides were equally used in all the facilities. COVID-19 may have had an effect on the rise in use of tetracycline in 2020 (doxycycline); this was observed in multiple facilities.

Analysis by AWaRe provides good insight into the appropriateness of prescribing/dispensing and helps set benchmarks based on WHO's target to use at least 60% of Access antibiotics. A very high consumption of 'Watch' antibiotics (such as azithromycin or ciprofloxacin) was observed across all facilities. It is important to note that all pharmacies are private pharmacies, and the availability of second and third-generation antibiotics are often more common in private facilities.

There were several limitations observed during curation and analysis. Importantly, unavailability of a data dictionary made it difficult to categorize the data and differentiate the units/ departments and their services. As the patient/admission numbers were inaccurate, it was difficult to determine the frequency of antimicrobials prescribed to an individual patient. Other data quality related issues observed during the analysis, such as missing/inaccurate denominator and numerators, posed a challenge to derive meaningful conclusions.

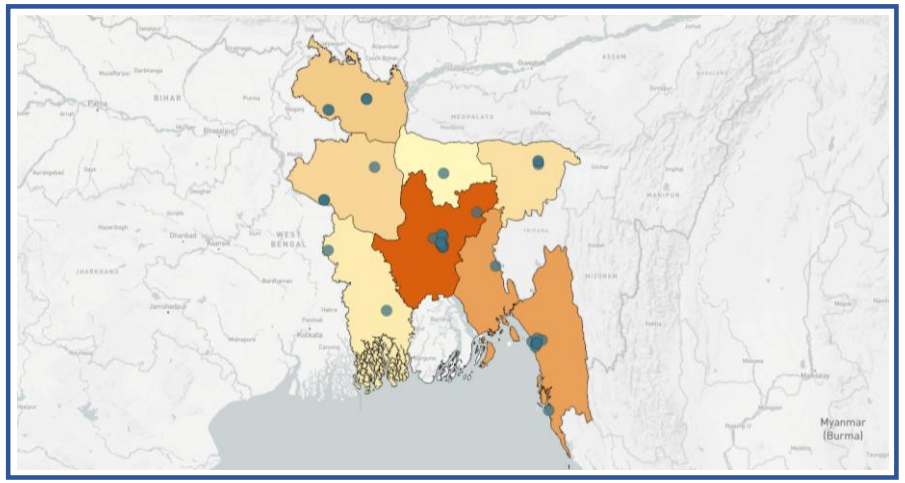
A standard data format with minimum variables, access to supporting documentation and tools, and inclusion of clinical data (indication, diagnosis, treatment) will help add to the richness of the data. Moreover, ensuring the quality of data (what and how it is recorded) should be focused on rather than increasing the quantity of records.

AMC data findings

During CAPTURA's scoping visit to Bangladesh in November 2019, the CAPTURA team was informed that AMC data collection activities were being carried out by a senior scientist associated with BSMMU with support from WHO-CO. To avoid duplication of activities, the CAPTURA team approached the scientist and discussed possibility of collaboration and technical assistance for data analysis. To date, the report remains unpublished, and the data is available with the research team and WHO-CO, Bangladesh.

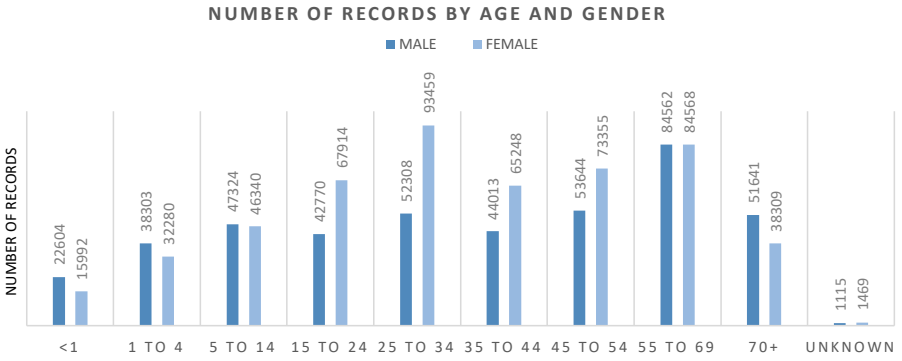
Based on the available AMU data provided by the 5 pharmacies, CAPTURA was able to conduct a sample hospital level AMC analysis. As AMC data indicates volumes of antimicrobials dispensed or used (e.g., at a hospital or pharmacy) and AMU data indicates how antimicrobials are used (e.g., what conditions are being treated, routes of administration), aggregating AMU data makes it possible to conduct an AMC analysis. This is possible because the data is derived from another, more granular, data source (dispensing records at patient level) along the pharmaceutical value chain. However, using AMC data to conduct an AMU analysis is not possible as key variables, such as indication or treatment duration, are absent. The sample Micro AMC analysis is available on page 33.

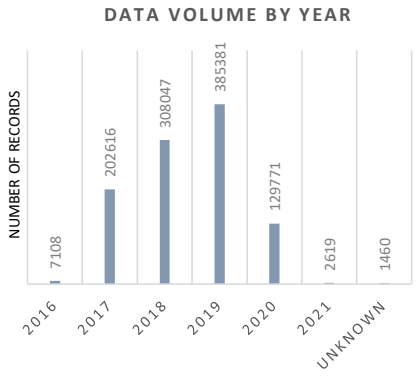
AMR Data Findings I

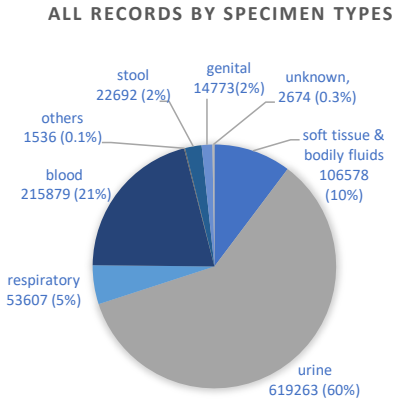


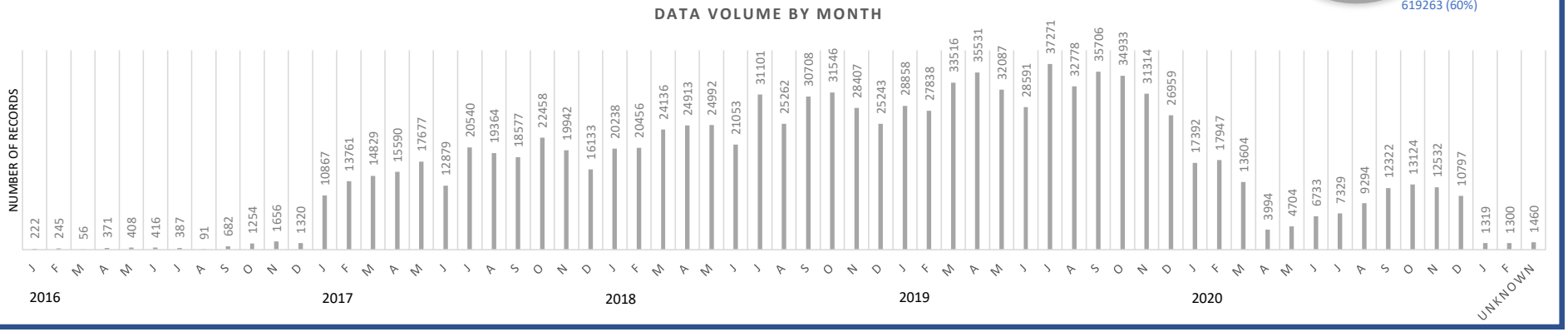
Bangladesh | 166 M | 34 facilities across the country

Total # of records = 1,037,002









AMR Data Findings II

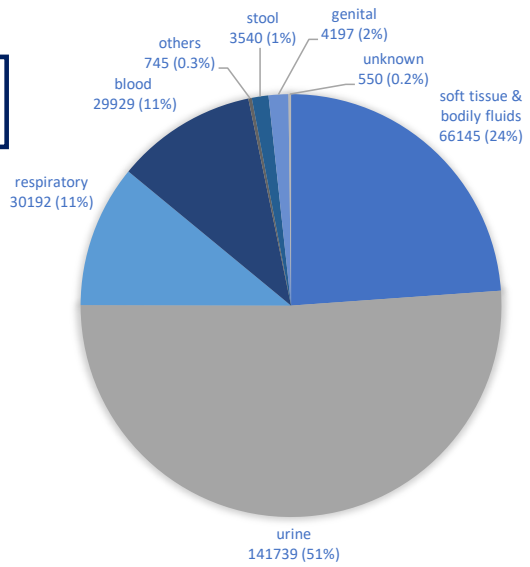
Total # of records = 1,037,002

EXCLUDED: Negative and null/missing results

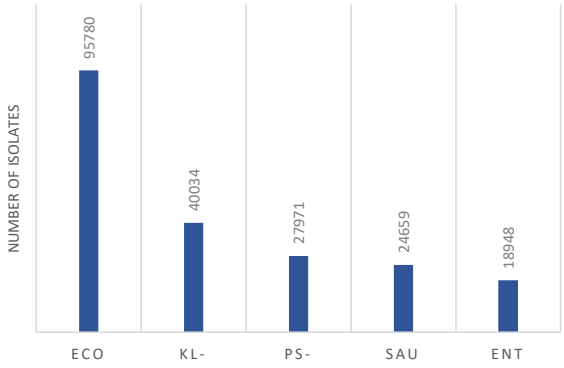
Positive culture results = 275,898

Organism code	Organism
AC-	Acinetobacter sp.
CAN	Candida sp.
ECO	Escherichia coli
ENT	Enterococcus sp.
KL-	Klebsiella sp.
PR-	Proteus sp.
PS-	Pseudomonas sp.
SAL	Salmonella sp.
SAU	Staphylococcus aureus ss.aureus
SCN	Coagulase negative Staphylococcus
SHI	Shigella sp.
STA	Staphylococcus sp.
STR	Streptococcus sp.

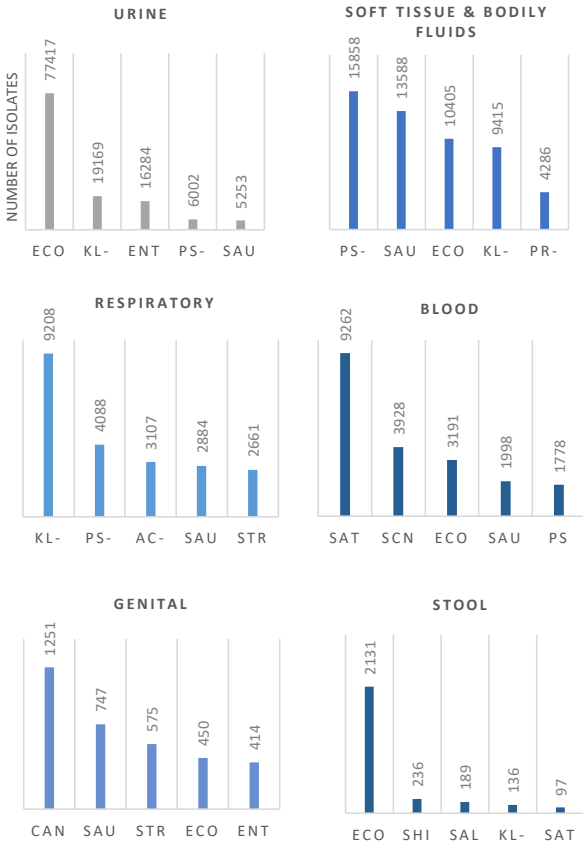
POSITIVE CULTURE RESULTS BY SPECIMEN TYPES

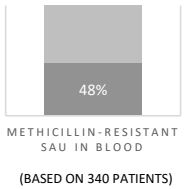


FIVE MOST COMMON ORGANISMS (FROM ALL SPECIMEN)



FIVE MOST COMMON ORGANISMS BY SPECIMEN





METHICILLIN-RESISTANT SAU IN BLOOD

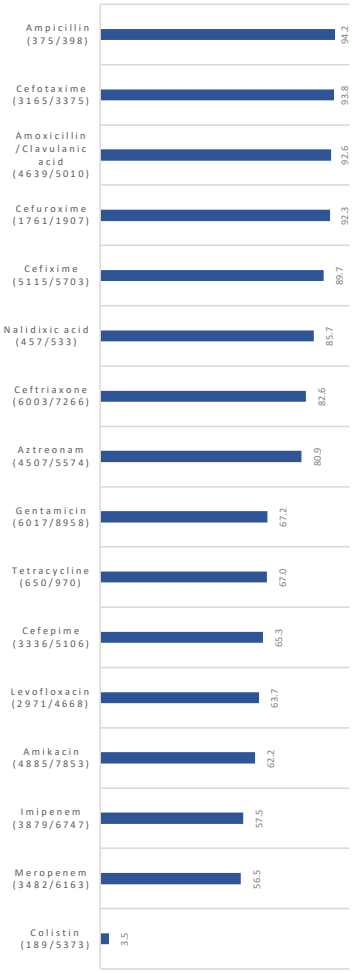
(BASED ON 340 PATIENTS)

ECO RESISTANT TO 3RD GEN. CEPHALOSPORIN

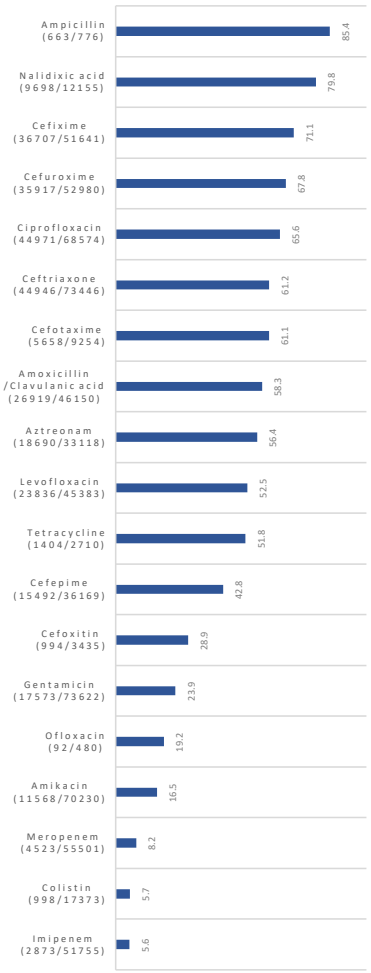
AMR Data Findings III

Antimicrobial RESISTANCE patterns of the five most important pathogens, tested against relevant antimicrobials. (number of resistant test results / total tests conducted)

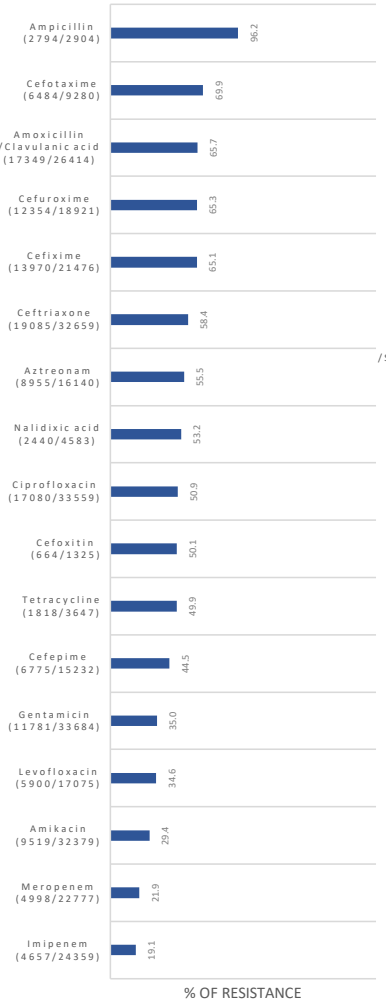
Acinetobacter sp. Antimicrobial Resistant Pattern (2016-2020)



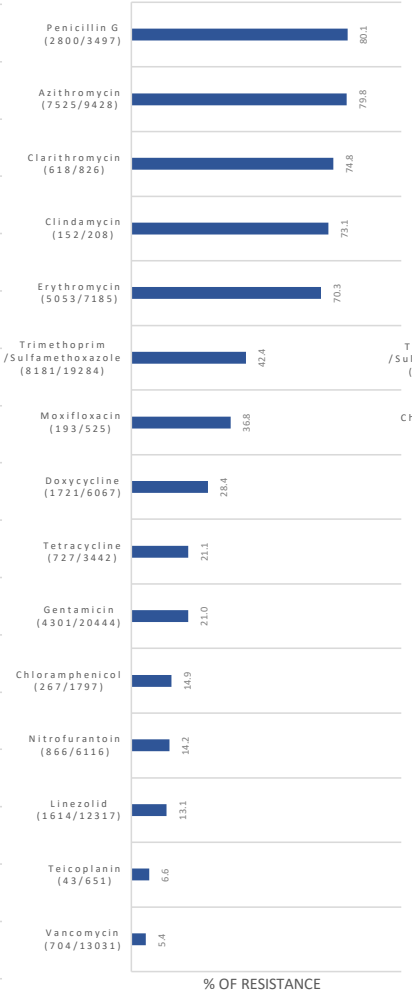
E.coli Antimicrobial Resistant Pattern (2016-2020)



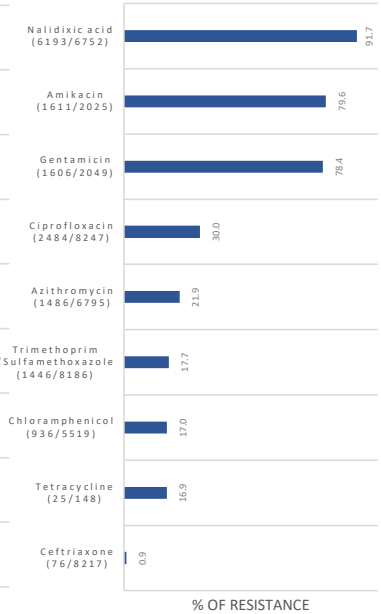
Klebsiella sp. Antimicrobial Resistant Pattern (2016-2020)



S.aureus Antimicrobial Resistant Pattern (2016-2020)



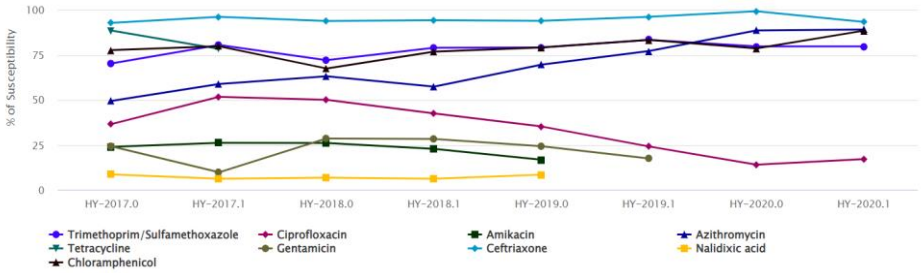
S.Typhi Antimicrobial Resistant Pattern (2016-2020)



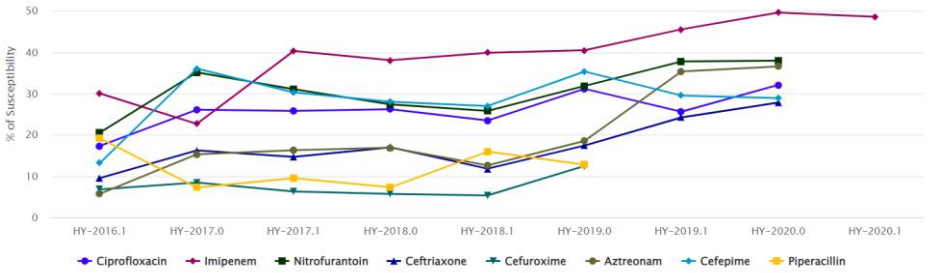
AMR Data Findings IV

Half yearly **antimicrobial SUSCEPTIBILITY trends** of the five most important pathogens, tested against relevant antimicrobials.

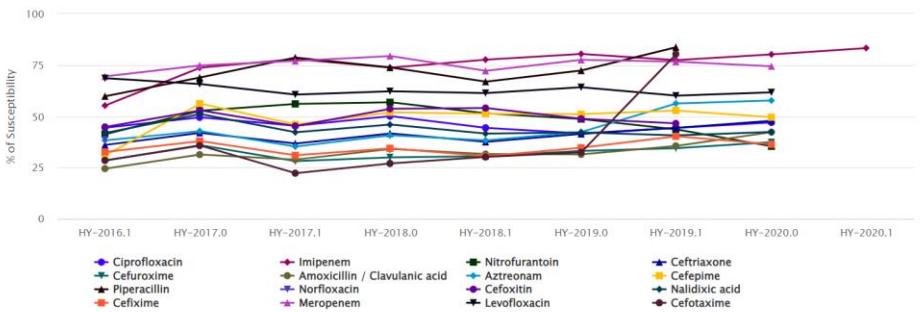
Half Yearly *S.Typhi*– Antimicrobial Susceptibility Trends over the period (2016-2020)



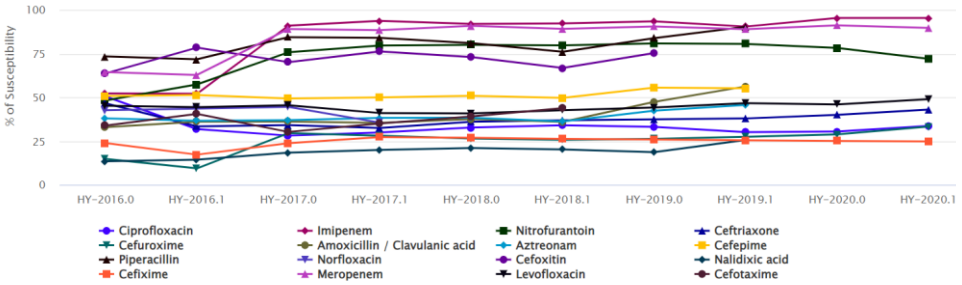
Half Yearly *Acinetobacter sp.* – Antimicrobial Susceptibility Trends over the period (2016-2020)



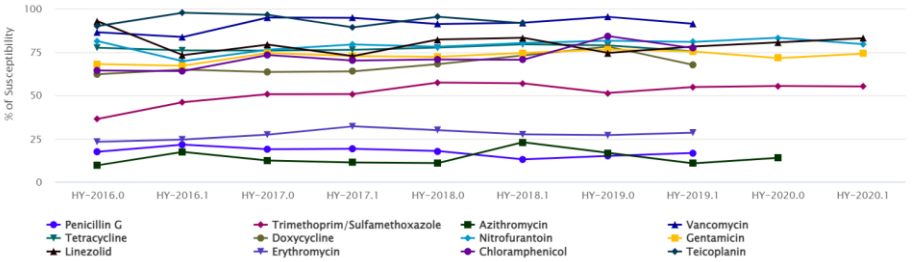
Half Yearly *Klebsiella sp.* – Antimicrobial Susceptibility Trends over the period (2016-2020)



Half Yearly *E. coli* – Antimicrobial Susceptibility Trends over the period (2016-2020)



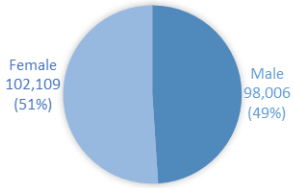
Half Yearly *S. aureus* – Antimicrobial Susceptibility Trends over the period (2016-2020)



Exemplary Hospital-AMC analyses derived from (in-patient) records

Data Source	Provider	Estimated Coverage	Limitation
Hospital Pharmacy Sales records (based on received prescriptions)	Private tertiary care hospital pharmacy	Limited coverage pertaining to one private facility	Analysis derived from existing patient records, without use of a specific AMU/AMC methodology

PRESCRIPTIONS BY GENDER

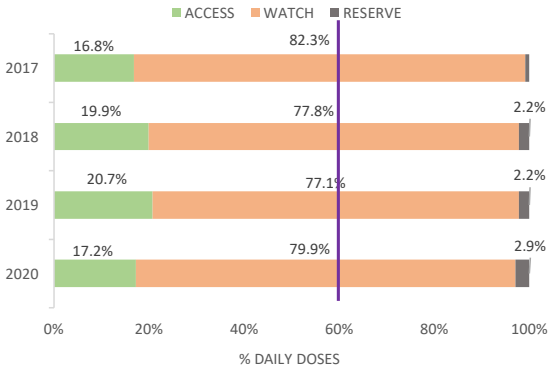


Top 5 oral and parenteral consumption/distribution of antimicrobials in 2017-2020

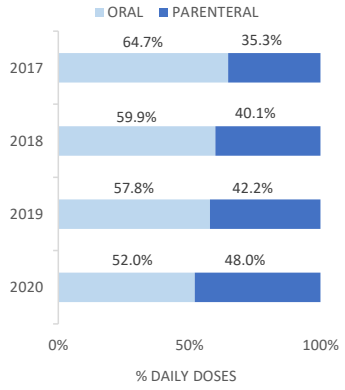
	Antimicrobial	Average % out of total ORAL consumption (2017-2020)	AWaRE
1	Cefixime	27.4	Watch
2	Cefuroxime	21.4%	Watch
3	Azithromycin	14.1%	Watch
4	Ciprofloxacin	7.6%	Watch
5	Metronidazole	6.4%	Access

	Antimicrobial	Average % out of total PARENTERAL consumption (2017-2020)	AWaRE
1	Ceftriaxone	48.8%	Watch
2	Amikacin	12.8%	Access
3	Metronidazole	11.7%	Access
4	Meropenem	6.2%	Watch
5	Moxifloxacin	3.9%	Watch

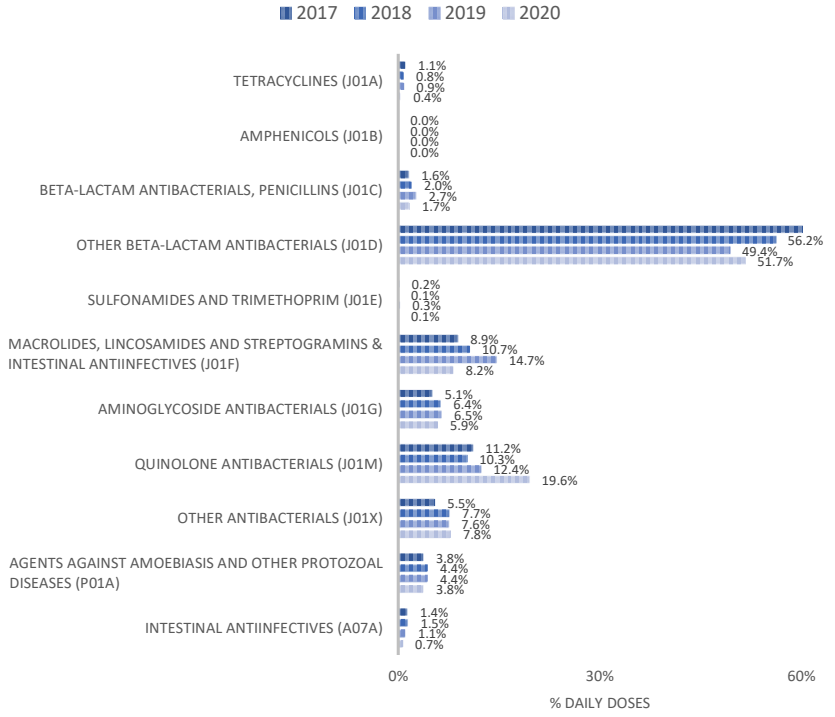
ANTIMICROBIAL CONSUMPTION BY AWARE CATEGORY



ANTIMICROBIAL CONSUMPTION BY ROUTE OF ADMINISTRATION



CONSUMPTION OF ANTIMICROBIALS BY PHARMACOLOGICAL SUBGROUP AT FACILITY LEVEL



SECTION

04

Conclusion

This final country report draft has served to summarize the experiences made through in-country implementation of CAPTURA activities in Bangladesh between June 2019 and June 2022. Also presented are the summary findings from the initial AMR and AMC/U data identification, assessment, and analysis. As noted above, most of the analysis and visualizations for the project were done using electronic visualization tools. Comprehensive analytical outputs and the visualization tools will be shared directly with participating stakeholders. The final data content of this report was selected after discussion with and feedback from data owners and relevant technical staff in the country, considering both reliability in terms of data quality as well as value of data sharing.

It is important to note that we believe the main utility of the data collected on AMR, AMC, and AMU through the CAPTURA project in Bangladesh is to help establish a preliminary data baseline, and that the activities have primarily enabled capacity building within data management and analysis for future AMR surveillance efforts.

AMR – limitations and recommendations

CAPTURA's findings demonstrate the availability of bacteriological culture and AST capacity in at least 90 facilities across Bangladesh, but this information needs to be verified through detailed scoping surveys. It is important for a country to have a list of all facilities generating AMR data that is regularly updated in order to understand current levels of capacity and prepare policies based on existing strength. CAPTURA identified major gaps in terms of QC (IQC and EQA), AST testing, and data management capacity. Having a strong quality management system at laboratories will ensure report and data validity and lead to acceptability of the findings by clinicians and researchers for their use in their respective domains. Hence, Bangladesh needs to initiate appropriate measures to enhance the capacity and quality of microbiology diagnostic services across the country, particularly focusing on IQC and EQA.

It was observed that laboratory staff are maintaining AST data where available, and through CAPTURA the technical staff involved in data generation and management were trained on the use of WHONET. Additionally, standardized testing procedures are in place, and designated NRLs are regularly providing training on common testing protocols. Therefore, it is now possible for the country to strengthen and potentially expand the existing AMR surveillance network by including private sectors. This is important in Bangladesh's context, as the private sector is an equal contributor in the health care sector and is generating quality data. It is thus necessary to bring them into a network and to use their available data for developing guidelines and policies for AMR containment. Also, efforts should be made towards long term sustainability of the network by using available local resources and developing a robust mechanism designed per the country context. This will allow for uninterrupted data sharing and continuous monitoring and tracking of AMR trends and patterns in the country, as well as the sharing of findings at local and international levels.

A process to digitize AMR data with support of CAPTURA has been initiated in facilities where laboratory management systems were not in place. This was enacted to ensure standardized data generation, and members at all facilities interested in data sharing were trained on the use of WHONET/BacLink software. These efforts can be continued with Bangladesh's active support for proper data recording and management for prospective use. IEDCR, which has been designated as an NRL, has the capacity to process all types of samples and specimens concerning public health and continues to provide quality oversight to the laboratories under its AMR surveillance network. With further capacity building and technical support from experts, this oversight can be extended to the newly identified facilities and beyond. Though it is not an absolute necessity, recording AST findings with zone diameters would help with using the data in the future if susceptibility breakpoints change over time. We also recommend the adoption of a set of standard antimicrobials to be promoted among laboratories, both to support routine clinical decision support needs and to improve comparability of findings over time within and between facilities. Equally important is to have uninterrupted supplies of reagents at the laboratory to ensure quality controlled outcomes and results.

Though IEDCR has been participating in EQAs for a long time, the absence of a Quality Management System for quality oversight and unavailability of quality control strain test results in the surveillance data shared with CAPUTRA raises questions on the quality of data being generated. It is recommended to maintain such records to validate the AST data generated by each laboratory. Further development and implementation of a more robust Quality Management System for ensuring consistent quality performance should be prioritized. If this happens,

IEDCR as an NRL could be established as an agency to provide quality oversight to the laboratories under the AMR surveillance network and beyond. Similarly, regular participation in an EQA program on both ID and AST by the NRL should continue as a routine practice. NRLs should identify such programs to enroll and upon establishment of microbiology capacity at referral sites, strengthening of a national proficiency testing program for bacterial culture, pathogen identification and AST is encouraged.

AMU – limitations and recommendations

Similar to CAPTURA's experience across other countries in the region, Bangladesh has very limited information readily available on AMU at the patient level. Recently, and with support of the FF Country Grant, PPS methodology for AMU has been introduced in the country to enhance efforts to begin AMU surveillance. The AMU data CAPTURA obtained was limited to a small cohort of pharmacies selected by convenience and can be considered an effort to scope data availability. This piloting exercise involved extraction of electronic drug sales records and identifying numerous gaps on the existing pharmacy record keeping practices. Although a huge volume of sales data was collected from different advanced pharmacies in Dhaka, information that could be gathered for meaningful analysis was limited. Diversity in data structure among different facilities made it extremely difficult for the CAPTURA AMU data curation and analysis team to develop a standardized process, and thus individual manual approaches had to be taken. This highlights the fact that existing pharmacy management systems currently used in Bangladesh may not be suitable for AMU monitoring. It is recommended that the relevant authorities identify minimum data variables that need to be recorded by each pharmacy in a standardized format to ensure data uniformity. It is important to ensure the quality of the data being generated for its use in developing plans and policies. Due to limited analytical scope of the collected data, only Hospital-AMC level analysis was possible, and showed the most frequently used antimicrobials in the facilities and consumption based on AWaRe classification. It is worth noting that findings suggest high use of "Watch" category antibiotics, which should be validated. More granular level data will be required for detailed analysis at the individual patient level, which is crucial to inform and evaluate antimicrobial stewardship interventions. If such data can be prospectively gathered across multiple facilities in a standardized manner, including consistent linkage to clinical and AMR data, it will truly represent a distinctive example of national AMU surveillance in the region. To further enable the establishment of this system, CAPTURA supported the DGDA by sharing the EXCEL AMU data collection tool and a minimal list of variables required for AMU analysis; these can be introduced after customization across major hospitals/pharmacies in the country. For this purpose, CAPTURA specifically recommends that:

1) Hospitals prioritize electronic prescription data capture wherever possible;

2) It is ensured that prescriptions include information on:

- basic patient and department demographics
- treatment duration and indication
- link to clinical diagnosis (and outcomes) as well as relevant lab information

This will allow for more granular assessment of the quantities used, and, most importantly, assessment of appropriateness of AMU.

AMC – limitations and recommendations

Since CAPTURA was not able to collect AMC data or support analysis of already collected data, specific recommendations could not be provided. As monitoring of AMC has not been done in a systematic manner in Bangladesh, it is important to acknowledge the activity led by BSMMU researcher. This activity should be continued prospectively, and findings of the work should be shared with key stakeholders for planning future efforts. Bangladesh is encouraged to collect and compare data across several years by establishing a robust AMU surveillance system to monitor AMC over time. Specifically, it would be advisable for Bangladesh to ensure that future data collection is done using templates that follow the WHO methodology, and that they facilitate easy collation and analysis. CAPTURA has developed a freely available data template which is already shared with DGDA, and a data visualization tool following WHO methodology that could be useful for such effort. This would allow monitoring of trends and eventually contribute to more systematic and quality data on AMC to the GLASS AMC module. Use of the template and tool would also allow for early detection of changes in AMC patterns that might merit further exploration, which may have policy implications and/or lead to stewardship interventions.

SECTION

05

Appendix

1. CAPTURA's data definitions

Project metadata constitutes all information collected directly by and as part of the CAPTURA project. This data includes:

- Information collected by landscape- and desktop-reviews, and from interviews on the names, function, and location of facilities etc.
- Information collected to identify, quantify, and prioritize data sources
- Information collected to assess the quality and relevance of data sources or facilities generating data

Most of the project meta-data is collected by questionnaires generated for the purpose of and administered by the CAPTURA project.

Project facility data is the actual retrospective source data from the identified facilities, which has been identified and prioritized for collection. This data includes historical AMR, AMU, or AMC data already collected in the facilities.

Antimicrobial resistance (AMR):
AMR data refers to microbiology laboratory data with a special focus on antimicrobial susceptibility test results of WHO priority pathogens[21] (excl. TB). This data may or may not include characteristics of the person from whom the sample was drawn. Examples of AMR data may be isolate level test results from microbiology labs or aggregate data on AMR testing from hospitals such as antibiograms.

To ensure consistency in categorization of identified AMU/C data sources during the project, the following definitions of AMU/C is used:

Macro Antimicrobial consumption (AMC):
Macro AMC refers to antimicrobial consumption statistics such as total sales, import or export in a country or region. Examples of Macro AMC data, for the purpose of CAPTURA project, include data on import and export of antibiotics and national distribution obtained from country's drug regulatory and similar authorities.

Micro Antimicrobial consumption (AMC):
Micro AMC refers to records of antibiotic procurement/supply/distribution at a district or facility level, but which does not hold data on individual dispensing. This data is often the only data available on antimicrobial use at a more granular level, and hence it is often used as a proxy for antimicrobial use. Examples of Micro AMC data, for the purpose of CAPTURA project, include procurement or inventory records from individual facilities (e.g., hospital pharmacies). *For Bangladesh, this term has been renamed as "Hospital-AMC".*

Antimicrobial use (AMU):
AMU data refers to records of dispensed antibiotics to individual patients (e.g., prescription data including patient information and potentially also information on indication or diagnoses). Examples of AMU data, for the purpose of CAPTURA project, include pharmacy-level records on dispensed antibiotics to patients/customers and are hence differentiated into the individual prescription level.

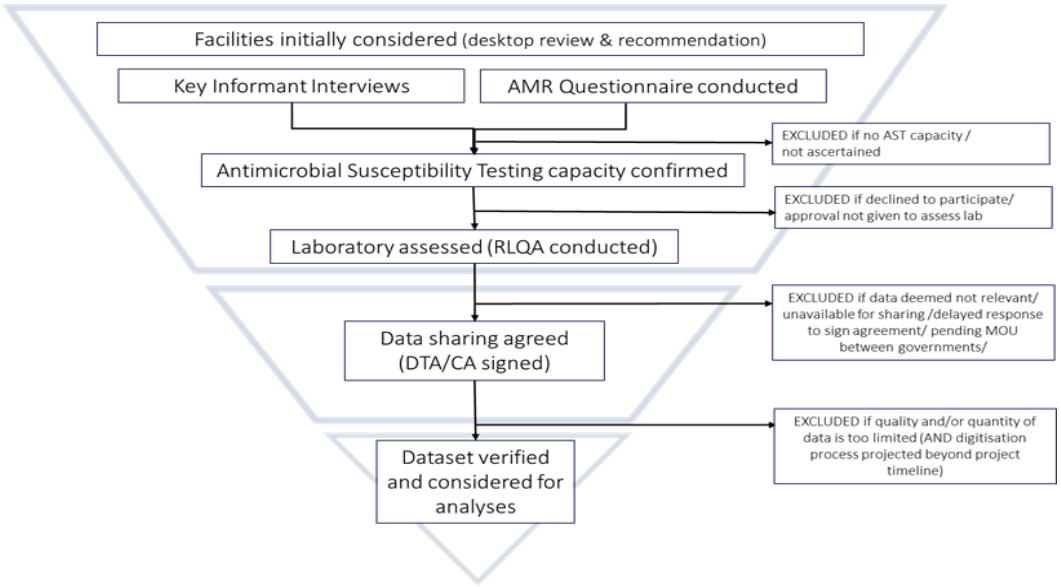
2. Metadata methodology

The AMR Questionnaire assisted CAPTURA and MOHFW to collect information on AMR data available at each facility, the methods used to collect it, the format of the stored data, and any additional indicators prior to collection of AMR datasets from each of the selected laboratories (see overview of variables in the next page).

A 'Rapid Laboratory Quality Assessment Tool for AMR' (RLQA) was used to rapidly assess selected quality indicators of laboratories' pathogen identification and antibiotic susceptibility testing for the past 3 years. The information was collected from a person who had access to the historical records and the necessary information regarding the laboratory, as well as adequate knowledge about the microbiology processes done at the laboratory for at least the past 3 years.

The RLQA assesses 7 sections: Equipment, Staffing, Media, Pathogen Identification, Antimicrobial Susceptibility Testing (AST), Internal Quality Control (IQC), and External Quality Assurance (EQA). It is important to note that the RLQA tool and the associated scores do not represent a comprehensive and validated microbiology lab assessment.

The AMU Questionnaire assisted CAPTURA and MOHFW to understand the AMU data available at each facility, the methods used to collect it, the format of the stored data, and additional indicators in prioritizing the facilities to be considered for future AMU surveillance (see overview of variables in the next page).



CAPTURA AMR Metadata and Priority Variables
Metadata
Facility Location
Public or private facility
Type of culturing conducted
Ability to conduct AST
How AST performed (automated or manual)
Average number of AST per month
AST data format (paper or electronic)
Number of years of available AST data
Presence of Laboratory Information System
Presence of internet connectivity at facility
Priority and Specialised Variables
Sample Origin (Human/Animal/Food)
Date of Birth/ Age
Sex
Patient Location (ward/clinic)
Healthcare Facility Admission Date (if inpatient)
Healthcare Facility Date of Visit (if outpatient)
Specimen Date
Specimen Type
Culture Result (organism isolated)
AST Interpretation (R, I, S)
AST Measurement (disk diffusion zone diameter/MIC value)
Antibiotics Prescribed After Specimen Collection
Diagnosis (after laboratory results provided)
Patient Outcome
Date and Cause of Death (if applicable)
Additional/Recurrent Isolates/Infections
Additional Patient Information (e.g., change in initial therapy, date of discharge, comorbidities, date of discharge, etc.)

CAPTURA AMU Metadata and Priority Variables
Metadata
Facility Location
Public or private facility
Located within a hospital/health centre
In-patient ward, Out-patient ward, Emergency Department
Number of staff working at facility and qualifications
Source of antimicrobials
Antimicrobial distribution data format (public or private)
Number of years of recorded data
Data format (e.g., paper or electronic)
Type of software used
Prescription linked to patient diagnosis
Ability to conduct data analysis
Presence of internet connectivity at facility
Priority and Specialised Variables
Patient Age
Patient Sex
Date of Prescription
Department (OPD, IPD, ED)
Type of Drug (Drug Class)
Ingredients
Strength of Drug
Formulation Type
Route of Administration
Product Name
Manufacturer
Pack Size Unit /Number of Doses Distributed
DDD
Indication for Prescription / Diagnosis
MDR Risk
Product Origin
Brand Name or Generic
Previous Antimicrobial Prescriptions
Change to Initial Therapy

3. Contents of CAPTURA's WHONET AMR reports for facilities

Epidemiology Report
1. Data volume
2. Patient and sample details
2.1 Patient demographics
2.2 Location details
2.3 Sample details
3. Organism statistics
3.1 Organism frequencies
3.2 Organism frequencies by specimen categories
3.3 Organism trends
4. Antimicrobial statistics
4.1 Gram-positive and Gram-negative antibiograms
4.2 Isolate alerts - Important resistance
4.3 Multidrug resistance: ECDC definitions of MDR/XDR/PDR
4.4 Multidrug resistance: Resistance profiles
5. Reporting to the World Health Organization and the United Nations
5.1 WHO Global Priority List of Antibiotic-Resistant Bacteria
5.2 WHO GLASS results
5.3 United Nations Sustainable Development Goals
6. Cluster detection
6.1 Cluster detection by species
6.2 Cluster detection by resistance profile
Appendix A. Antibiograms
Test practices and quality report
1. Data entry and management
1.1 Data volume
1.2 Completeness and validity of data entry
2. Quality control testing
3. Organism results
3.1 Capacity for organism identification
3.2 Capacity for the isolate of fastidious organisms
3.3 Blood culture results
4. Antimicrobial susceptibility test practices
4.1 Antibiotic Configuration
4.2 Antibiotic tests without validated breakpoints
4.3 Regularity of antimicrobial testing
4.4 Antimicrobial susceptibility test measurements
5. Quality control alerts

4. AMC Methodology

The consumption data in this report were collated by CAPTURA by applying the WHO protocol on surveillance of AMC.[14]

CAPTURA uses the Anatomical Therapeutic Chemical (ATC) classification system[15] to classify antimicrobial substances and the number of DDDs as a measurement metric. The DDD is the assumed average maintenance dose per day of an antimicrobial substance(s) used for its main indication in adults and is assigned to active ingredients with an existing ATC code. As a rule, the DDDs for antimicrobials are based on treatment for infections of moderate severity. To adjust for population size, the consumption is usually presented as number of DDDs per 1000 inhabitants per day. The 2019 ATC/DDD version is used by CAPTURA to present the data for all reporting years.

AMC is presented using the following key indicators:

- Quantity of antibiotics as DDD per 1000 inhabitants per day for total consumption and by pharmacological subgroup (ATC3);
- Relative consumption of antibiotics as a percentage of total consumption by route of administration (oral, parenteral) and AWaRe categories (Access, Watch and Reserve)[16];
- List of the most frequently used antibiotic substances comprising 75% of the total consumption, stratified by route of administration-Drug Utilization 75 (DU75).

AWaRe Categorization

Antibiotics of the WHO Model List of Essential Medicines List are grouped in 3 AWaRe categories: Access, Watch and Reserve. The AWaRe classification covers 177 commonly used antibiotics, with the aim of supporting antibiotic monitoring and stewardship activities. The Access category includes first and second choice antibiotics for the empirical treatment of common infectious syndromes, and these should be widely available in health care settings. Antibiotics in the Watch category have a higher potential for resistance to develop, and their use as first and second choice lines of treatment should be limited. Finally, the Reserve category includes “last resort” antibiotics, whose use should be reserved for specialized settings and specific cases where alternative treatments have failed. In this report, the consumption data presented were grouped according to the WHO AWaRe categorization, revised in 2019.

DATA visualization

CAPTURA has designed and engineered a tool to enable visualization of the AMC data collected as part of the project. The tool is a pre-coded template, which can be used by individual facilities/countries to build their own individually tailored and interactive AMC dashboard files.

The template, including guidance on how to use it, is freely available on: https://captura.ivi.int/

[14] World Health Organisation. WHO methodology for a global programme on surveillance of antimicrobial consumption v1.0

[15] WHO Collaborating Centre for Drug Statistics Methodology. Guidelines for ATC classification and DDD assignment 2020. 2019

[16] World Health Organisation. WHO 2019 AWaRe Classification Antibiotics https://www.who.int/medicines/news/2019/WHO_releases2019AWaRe_classification_antibiotics/en

5. AMU Methodology for Bangladesh

The majority of pharmacies in Bangladesh are hospital pharmacies, that record and store sales data electronically using pharmacy management systems or a module of hospital management information systems. The CAPTURA in-country team evaluated these recording platforms and shared an excel template (based on the GLASS methodology for surveillance of AMC and AMU) to the software development team. The team in turn, developed a function to export CAPTURA expected data and share with the CAPTURA in-country team. The curation was done in two stages (preliminary and detailed curation):

The preliminary curation was performed using a custom web-based application (AMU Curator) developed by the CAPTURA team. The datasets from the different facilities were pulled together into a single database to be curated together.

The curation consisted of:

- Personal identifiers were encrypted and any age over 70 was grouped together
- Any items that were not antimicrobials and those for local use, (e.g., on the skin, ears, eyes, nose, and vagina), were excluded
- Grouped Information in the trades name variable were separated into distinct variables (generic name, strength, formulation, units, and route of administration)
- Calculated treatment duration by subtracting date of release and date of admission
- Utilizing a list containing the CAPTURA antimicrobials, generic name, ATC code (J01 - antimicrobials for systemic use, A07AA and P01AB), Route of Administration, DDD, and DDD Unit, we crosschecked the antimicrobials and attached the new variables (drug code, AWaRE category, ATC code, Route Admin, DDD, and DDD units).
- Any discrepancies were double-checked in the "DIMS" mobile application and updated accordingly.

Following the preliminary data curation, the datasets were uploaded to the CAPTURA warehouse for further detailed cleaning and analysis.

After a standard dataset exploration, cleaning was performed to recode any observations or variables containing typos and to regroup certain observations and variables as deemed necessary for performing analysis and visualizations. Missing values were also removed.

The detailed curation consisted of:

- Patient age was recorded in 3 distinct variables of Age in Years, Months, and Days; for analysis purposes, it was recoded as a single age group variable of patients: Under 1 years of age, followed by 5-year ranges between 1 and 70 years and over 70 years of age
- Removing any combination antimicrobials that are not part of the CAPTURA analysis (included J01 - antimicrobials for systemic use, A07AA and P01AB)
- The antimicrobials were grouped into pharmacological subgroups following the ATC3 coding system
- Strength was turned into grams
- Missing strengths and volumes of syrups/suspensions were found and then assigned the appropriate formulations based on their trade names using a google search

For the Hospital-AMC analysis, only individual analysis per facility has been conducted.

For each facility and year, we calculated:

- Quantity of antibiotics as DDD per 100 patients for total consumption
- Quantity of antibiotics as DDD per 100 patients by pharmacological subgroup
- Quantity of antibiotics as DDD per 100 patients by AWaRe category

The patient numbers (denominators) came from grouping and aggregating the unique IDs, gender, and age of the patients and counting the number of occurrences. Once the duplications were isolated, unique individuals were counted per year and that comprised the patient numbers.

The detailed curation, analysis and visualizations were performed using R statistical software.