Original Article

Antibiotic Shortages among Public Sector Hospitals Across Sub-Saharan Africa: A Protocol for an Electronic Survey to Gain Understanding

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Abstract

Background: Antibiotic shortages in public hospitals across sub-Saharan Africa represent a growing public health crisis, increasing antimicrobial resistance (AMR). While European countries have conducted several surveys on medicine shortages, similar data are scarce in sub-Saharan Africa. Ensuring the availability of critical antibiotics among hospitals across Africa is essential for effective treatment of infectious diseases and for implementing targeted Antimicrobial Stewardship Programmes (ASPs) to reduce AMR. **Objective**: To evaluate the scope, causes and potential solutions regarding antibiotic shortages in public sector hospitals across sub-Saharan Africa. Subsequently, use the findings to make recommendations for future strategies, including ASPs. **Methods**: A cross-sectional descriptive survey will be undertaken among hospital pharmacists, nurses, physicians and other healthcare professionals across sub-Saharan Africa. An electronic questionnaire, based on the European Association of Hospital Pharmacists (EAHP) model and available in English, French and Portuguese, will gather data on the frequency, types, causes and proposed solutions to antibiotic shortages in hospitals. The survey will run for two months, leveraging existing professional networks to enhance participation. Open-ended responses will be summarised in in Excel. Descriptive statistics will include frequencies, percentages, means and standard deviations, and will be calculated using STATA® to summarise both categorical and continuous variables. **Discussion and Conclusion**: This study will provide comprehensive data on the prevalence and drivers of antibiotic shortages in public hospitals in this important region. The findings will inform national and regional health policies, strengthen supply chain resilience and support ASP implementation. This will be the first time that such a comprehensive survey will be conducted across sub-Saharan Africa as part of the drive to reduce AMR.

Keywords: Antibiotic shortages, antimicrobial resistance, antimicrobial stewardship, AWaRe classification, public hospitals, sub-Saharan Africa, supply chains

Introduction

Shortages of key antibiotics are a major global public health concern, with adverse consequences for patient safety, treatment outcomes and antimicrobial resistance (AMR).[1,2] Shortages can result in the need to prescribe less appropriate or less effective antibiotics. This includes the overuse of broad-spectrum antibiotics which often leads to higher costs due to the prescribing more expensive antibiotics. Shortages of key antibiotics may also lead to the transfer of patients to other facilities possibly transmitting infections, as well as patients being discharged early, both contributing to the rising burden of AMR.[1,3-9] AMR is a particular concern among sub-Saharan African countries, with rates continuing to rise.[10-12]

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Whilst hospitals and communities across countries have been affected by antibiotic shortages,[3,4,13] most documentation of shortages of medicines in hospitals, including antibiotics, has come from high-income countries as well as across Europe through groups including the European Association of Hospital Pharmacists (EAHP).[6,14-18] EAHP surveys have found shortages of essential antibiotics, which include the penicillins and cephalosporins, and are attributable to problems with production, financial issues and legal restrictions.[9,16,17] This has led to proactive approaches across Europe to address potential and actual shortages of antibiotics. These include prospective risk assessments as well as healthcare failure mode and effect analyses to help address potential areas of concern, which includes possible substitution policies and improvements in stock control.[6,15,17,19]

To date, there have only been a limited number of studies across Africa assessing concerns with shortages of medicines in hospitals, the underlying causes and potential ways forward. Possible courses of action comprise increased local production of medicines, including antibiotics, as well as improving the rational use of medicines in hospitals, which includes antibiotics, to concentrate only on key medicines and doses to improve stock control.[20-22] Affordability, available finances and greater proactivity are also key considerations that need to be addressed across Africa to reduce shortages.[23,24] To date, there have only been a limited number of studies conducted among African countries to assess the extent of shortages of antibiotics, especially in hospitals, and potential ways forward. This includes a study from Ethiopia alongside comments concerning antibiotic shortages in neonatal intensive care units in Malawi.[7,25] There have also been concerns with shortages of antibiotics among hospitals in Kenya; however, not to the same extent.[26,27] In addition, there are likely to be shortages of medicines, including antibiotics, in hospitals in Nigeria following an appreciable recent rise in the cost of antibiotics.[28] The potential for therapeutic interchange policies among antibiotics to address issues of shortages is discussed in the paper of Chigome *et al*. (2019). However, to date, there was little evidence of such activities among public hospitals in South Africa and across sub-Saharan Africa.[4]

Critical global initiatives to reduce AMR include classifying antibiotics into categories of Access, Watch and Reserve antibiotics (AWaRe system) based on their resistance potential, with the emphasis on reducing the extent of use of Watch and Reserve antibiotics.[29-31] More recently in 2022, the WHO AWaRe book was launched giving guidance for the management of 35 infectious diseases across both hospital and primary care.[32,33] The emphasis is on increasing the prescribing of Access antibiotics where antibiotics are indicated through agreed quality indicators and other antimicrobial stewardship activities.[34-36] There have been concerns that Antimicrobial Stewardship Programmes (ASPs) are more difficult to perform in low- and middle-income countries (LMICs), including African countries.[37] However, this is now changing, and we are seeing an increasing number of ASPs being undertaken across all sectors among sub-Saharan African countries.[35,38-42] Such activities are important given ongoing concerns with current antibiotic utilisation patterns across all sectors in sub-Saharan Africa and associated AMR.[20,38,43-46] In addition, if there are concerns with how healthcare professionals (HCPs) who are still in training handle the prescribing of antibiotics in hospitals, including often limited adherence to current guidelines, such activities could have a negative impact on subsequent prescribing and dispensing of antibiotics in primary care once qualified.[47-49]

Consequently, there is an urgent need to comprehensively assess the extent of antibiotic shortages among all hospital types across sub-Saharan Africa, including primary, secondary and tertiary hospitals. This includes essential antibiotics listed in the WHO AWaRe guidance, coupled with the potential reasons for current antibiotic shortages, to improve the future care of patients hospitalised with infectious diseases across sub-Saharan Africa. Such a study will build on the findings of EAHP surveys as well as the limited number of studies conducted to date across Africa.[4,6,7,14,16,17,25] By identifying the frequency, drivers and impact of antibiotic shortages among sub-Saharan African countries, alongside potential solutions proposed by pertinent HCPs, including clinicians, hospital pharmacists and those involved with the procurement of antibiotics, this should generate actionable insights for key stakeholder groups going forward. This is particularly important given that antibiotic shortages may compromise ASPs.[7,9] As a result, it is likely that potential activities across sub-Saharan Africa will include strengthening supply chain transparency as well as implementing policies to enhance equitable access to affordable antibiotics in line with WHO goals.[7,20,50-52]

Protocol

Aim of the study

To evaluate the scope, causes and potential solutions to antibiotic shortages among public sector hospitals across sub-Saharan Africa.

Study objectives

i. To document the prevalence and types of antibiotic shortages experienced in public sector hospitals across sub-Saharan Africa.
ii. To identify essential antibiotics affected by shortages, particularly those in the WHO AWaRe guidance book.
iii. To explore the perceived causes of antibiotic shortages from the perspective of hospital frontline HCPs, including pharmacists, physicians, nurses and other pertinent HCPs, as well as personnel involved in the procurement of antibiotics for hospitals, if different.
iv. To evaluate the potential impact of antibiotic shortages on clinical decision-making and AMR.
v. To gather recommendations from key HCPs on potential feasible interventions and policy solutions to reduce or manage antibiotic shortages in public sector hospitals across sub-Saharan Africa.

Study design

This study will employ a descriptive cross-sectional study design, using an online electronic questionnaire across sub-Saharan Africa, targeting frontline HCPs working in public sector hospitals and personnel involved in the procurement of antibiotics for hospitals, if different from the targeted HCPs.

Study setting

For diverse perspectives and expertise, public sector hospitals across a diverse range of countries and regions in sub-Saharan Africa will be purposively selected to provide rich data on antibiotic shortages. A range of sub-Saharan African countries, aimed at providing a selection of countries by geography, population size and income levels, will be invited to participate in the study. These include but are not limited to Angola, Botswana, Burkina Faso, Cameroon, Congo, Eritrea, Eswatini, Ethiopia, Gambia, Ghana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, Zambia and Zimbabwe. With this approach, we are aiming to minimise any bias with the findings. We have adopted this approach before, when exploring and describing the management of infectious diseases, as well as non-infectious diseases, across all sectors in sub-Saharan Africa in recent years.[20,38,43,53-57]

Target population and sample selection

The target population will be HCPs working at public sector hospitals in sub-Saharan Africa, including hospital pharmacists, nurses, physicians and other HCPs who prescribe, dispense, administer or procure antibiotics. The rationale for the target population is because of their responsibility of coordinating the provision of essential medicines to patients or various healthcare facilities and the treatment of patients in hospitals for infectious diseases. Consequently, they are in a position to provide valuable input to meet the stated objectives of this study. When there are differences in the findings between personnel within a specific sub-Saharan African hospital, the view of the hospital pharmacy personnel will predominate as they are the group of HCPs most cognisant with current supplies of antibiotics in hospitals as well as issues of shortages of essential medicines, including antibiotics.

There are no sample size calculations for this study. This is due to the very limited number of published studies currently documenting the extent of antibiotic shortages in hospitals across sub-Saharan Africa. This is apart from individual studies, including Chigome *et al.* and Alemkere *et al*.[4,25] Evidence shows a similar situation regarding the EAHP studies on medicine shortages across Europe.[14-17] However, efforts will be made to ensure that a comprehensive and diverse range of sub-Saharan African countries, as well as relevant personnel, are included in the study, building on previous successful studies undertaken by the co-authors across the continent.[20,38,43,53-57]

Purposive and snowball sampling will be used to select public sector hospitals and participants across a diverse range of sub-Saharan African countries, ensuring a representative sample. Existing contacts across sub-Saharan Africa will be used purposively to identify participants within their networks, and then for those participants to further use snowball sampling to recruit additional participants within their networks, among hospitals in their respective countries. The target will be at least five public sector hospitals per sub-Saharan African country.

The following inclusion criteria will apply: (i) any general public sector hospital, i.e. primary, secondary or tertiary hospital, with in-patient beds among sub-Saharan African countries, (ii) key hospital personnel involved with prescribing, monitoring and procuring/supplying antibiotics and (iii) respondents providing informed consent. Exclusion criteria will include: (i) any private sector hospital and (ii) any specialised public sector hospital, e.g. mental health/psychiatric hospital, hospitals dealing predominantly with cancer patients or those with cardiac disease or specialised tuberculosis hospitals.

Data collection instrument and pre-testing

The structured questionnaire for this study has been adapted from the EAHP model, combined with additional input from the literature alongside the experience from the co-authors in this area, as no comprehensive questionnaire currently exists for this situation.[4,6,14-17,19,58] The English version of the draft questionnaire is available in Supplementary Table 1. The questionnaire is structured according to five main sections and includes both open-ended and closed questions. Section A focuses on demographic information, Section B on antibiotic shortages, especially those contained within the WHO AWaRe guidance book [Table 1] and Section C on potential strategies dealing with antibiotic shortages. Section D subsequently explores the impact of antibiotic shortages on patients followed by Section E, which concentrates on antibiotic shortages and possible stewardship activities.

The principal researcher (MM) will format and convert the questionnaire into Google Forms, which is a web-based tool included in the Google suite (https://docs.google.com/forms/u/0/?pli=1). This platform is suitable as it allows for the creation of an online survey integrating checkbox options, multiple choice options and short answer fields, promoting and facilitating efficient data analysis. The electronic format of the data collection instrument will include conditional logic, allowing respondents to be directed to relevant sections based on their answers, which will streamline the responding process to enhance interest and use.

The draft questionnaire will subsequently be pre-tested among key personnel in three hospitals in three different sub-Saharan African countries to ensure content validity and face validity. The pre-testing will also be used to determine the approximate time needed to complete the survey. These personnel will subsequently be excluded from the actual study; however, other hospitals in the participating countries will still be part of the actual study.

Table 1: Key antibiotics listed in the WHO AWaRe (Access, Watch, Reserve) guidance book[32,33]

AWaRe classification	Antibiotic (oral/intravenous depending on the infection)
Access	Amikacin
	Amoxicillin
	Amoxicillin/clavulanic acid
	Ampicillin
	Benzathine benzylpenicillin
	Benzylpenicillin
	Cephalexin
	Chloramphenicol
	Clindamycin
	Cloxacillin
	Doxycycline
	Gentamicin
	Metronidazole
	Nitrofurantoin
	Phenoxymethylpenicillin
	Procaine benzylpenicillin
	Spectinomycin
	Sulphamethoxazole + trimethoprim
	Trimethoprim
Watch	Azithromycin
	Cefazolin
	Cefixime
	Cefotaxime
	Ceftriaxone
	Ciprofloxacin
	Clarithromycin
	Meropenem
	Piperacillin + tazobactam
	Vancomycin
Reserve	Ceftazidime + avibactam
	Cefiderocol
	Colistin
	Fosfomycin
	Linezolid
	Meropenem + vaborbactam

Based on the findings of the pre-test alongside input from the respondents, the questionnaire will be revised, incorporating any necessary refinements. Once finalised, the questionnaire will be translated into French and Portuguese using back-translation. Professional translators will conduct both the initial translations and the back-translations. Any discrepancies identified will be carefully reviewed and resolved to ensure accuracy and equivalence of meaning. The French and Portuguese versions of the survey will also be made available on Google Forms.

Data collection process

Data collection will only proceed after ethical clearance has been granted and successful completion of the pre-testing and translation of the questionnaire. The target personnel in each of the participating hospitals will be sent an email inviting them to participate in the survey. The email will include a detailed explanation of the study and its purpose, likely time required to complete the survey (based on the findings of the pre-testing) and that consent will be required for participation. Those who agree to participate in the study will be requested to click on a dedicated link provided in the email, which will direct them to the online Google Forms questionnaire. The introduction to the questionnaire will include the same information as in the email, including a clear consent statement. The consent statement will explain to the participating HCPs that by completing and submitting the survey, they are providing their informed consent to take part in the study. Participants who agree to participate in the study will have to click on a mandatory 'YES' button, confirming their consent, after which they will be able to access the questionnaire. Those who do not click on the mandatory agreement will not have access to the survey.

An email list will be provided to the principal researcher (MM) through the contacts in each country, who will also be used to help follow up the initial email to enhance response rates. The principal researcher will be responsible for monitoring and collating responses, as well as issuing weekly reminders to encourage participation. The principal researcher will also oversee the quality assurance of the data, which includes verifying the completeness and consistency of the submitted responses. Data will be collected over a period of two months with weekly email reminders to enhance the response rate.

Data management and analysis

All datasets will be cleaned before analysis by checking for missing, inconsistent or incomplete data. Descriptive statistics will be used to summarise the data. Data from open-ended questions will be captured into Microsoft Excel® (Microsoft corporation, Washington United States of America), coded and categorised to enable counting of responses as well as providing meaningful descriptions within categories. Descriptive statistical analysis will be conducted using STATA® software (STATAcorp, Texas, United States of America). Frequencies and percentages will be calculated to summarise categorical variables. Means with standard deviations and medians with interquartile ranges will be used to summarise continuous variables.

Reliability, validity and bias

To ensure reliability, the survey will use a standardised questionnaire administered uniformly through Google Forms. Pre-testing will be employed with a small group of HCPs who will not be part of the final sample to identify and correct ambiguities and ensure that the tool consistently measures what it is intended to measure across the different hospital types and countries. Face and content validity will be established through expert review and alignment with existing literature on antibiotic shortages and health systems across LMICs, including sub-Saharan African countries. Survey questions will be carefully worded to be neutral and non-leading to reduce the risk of bias. Data collection will follow a predefined, transparent protocol to maintain impartiality. All datasets will be cleaned before analysis.

Measures to minimise bias will be employed. Pre-testing of the questionnaire will account for recall, language or

interpretation and instrument bias. Although response bias may occur, anonymity and neutral phrasing will be used to reduce the risk. We recognise that this study might be subject to sampling/selection bias. However, as many sub-Saharan African countries as possible will be included in this study to help mitigate sampling/selection bias. These countries will represent a broad range of sub-Saharan African countries by geography, population size and income levels. Weekly reminders will be sent to all identified participants to account for or minimise participation bias.

Expected outcomes

The principal expected outcomes of the study will be:

- Documenting the current prevalence and types of antibiotic shortages among public sector hospitals across sub-Saharan Africa, especially key antibiotics recommended in the WHO AWaRe book guidance[33,59]
- Ascertaining the perceived causes of antibiotic shortages among public hospitals across Africa and their potential impact on clinical decision-making and AMR
- Compiling a comprehensive list of recommendations regarding potential feasible interventions and policies that can be introduced among public hospitals in sub-Saharan Africa to reduce or manage future antibiotic shortages.

Ethical considerations

Ethical approval has been granted from the Sefako Makgatho University Research Ethics Committee, where the principal researchers are based. Approval for conducting the study will be obtained from different countries and authorities as required. Participants will be well informed about the study, its objectives, procedures, potential risks and benefits before providing informed consent. Confidentiality will be maintained by allowing participants to complete the questionnaire anonymously, with no personal identifiers collected. Each online response will be assigned a timestamp by the electronic system according to the date and time the user completed the questionnaire. All data will be securely stored in password-protected and cloud-based storage until 5 years after the results have been published. After this period, the data will be permanently destroyed in accordance with the university's data management and retention policies.

Project plan

Table 2 depicts the project activities, including dissemination of results, and proposed timelines. The project is anticipated to be executed over a period of approximately 12 months.

Conclusion

We believe this comprehensive study and its findings will provide invaluable information to all key stakeholders across sub-Saharan Africa and wider to help improve the availability and use of antibiotics in public hospitals. This is critical for sub-Saharan Africa, given rising AMR rates and the subsequent impact on morbidity and mortality in this critical region.

Financial support and sponsorship

Nil.

Table 2: Project activities and anticipated timelines

Activity	2025								2026		
	April	May	June	August	September	October	November	December	January	February	March
Research protocol development											
Protocol submission to SMUREC											
SMUREC review and granting of clearance											
Permissions from participating countries											
Submission of the protocol for publication											
Pre-testing of the questionnaire											
Electronic questionnaire refinement and review											
Translation of electronic questionnaire											
Manuscript on pre-testing of questionnaire											
Distribution of questionnaire and reminders											
Data analysis and interpretation											
Report writing											
Dissemination of report to all participating countries											
Conference abstract submission											
Manuscripts for publication											

NB: SMUREC: Sefako Makgatho Research Ethics Committee

Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1 Questionnaire

Introduction and informed consent

We kindly invite you to participate in a survey by completing an online questionnaire, which will take approximately twenty minutes of your time. The overall aim of the study is to evaluate the scope, causes and potential solutions to antibiotic shortages among public sector hospitals across sub-Saharan Africa. The specific study objectives are: (i) to document the prevalence and types of antibiotic shortages experienced in public sector hospitals across sub-Saharan Africa; (ii) to identify essential antibiotics affected by shortages, particularly those in the WHO AWaRe guidance; (iii) to explore the perceived causes of antibiotic shortages from the perspective of hospital frontline healthcare professionals (HCPs) including pharmacists, physicians, nurses and other pertinent HCPs, as well as personnel involved in the procurement of antibiotics for hospitals, if different; (iv) to evaluate the potential impact of antibiotic shortages on clinical decision-making and antimicrobial resistance; and (v) to gather recommendations from key HCPs on potential feasible interventions and policy solutions to reduce or manage antibiotic shortages in public sector hospitals across sub-Saharan Africa.

The study has received ethical clearance from the Sefako Makgatho University Research Ethics Committee, which can be contacted at: +27 12 521 5617/3044 or lorato.phiri@smu.ac.za. By completing this survey, you acknowledge that you have read and understand the above aim and objectives of the study and hereby give informed consent to participate in this survey. Your responses will be anonymised, meaning your identity will not be linked to your answers. All data will be treated confidentially, ensuring your participation poses no risk. The study will not directly benefit you personally, but it is anticipated that based on survey responses, actionable insights and potential activities for key stakeholder groups will be generated. We anticipate that this will result in activities across sub-Saharan Africa to strengthen supply chain transparency, and the implementation of policies to enhance equitable access to affordable antibiotics, in line with the World Health Organization's goals to curb the spread of antimicrobial resistance.

Participation in the study is voluntary and you may withdraw from it at any point. Should you choose not to participate, this will not be held against you in any way. Should you have any questions, please feel free to contact one of the study investigators at [Investigator 1 Contact Info] or [Investigator 2 Contact Info].

Agree - Click on [YES] (Mandatory question)

To continue with the survey, click on [NEXT].

Survey questions

Please select the applicable option(s)/answer(s) in the dropdown menu provided or provide text where applicable.

Section A: Demographic data

Number	Questions and filters	Participant's response and coding categories
1	Country	Dropdown menu with sub-Saharan African countries
2	Years of practice in a public hospital	Dropdown menu with numbers
3	Designation	Pharmacy manager…… 1
		Pharmacy store manager…… 2
		Procurement pharmacist…… 3
		Clinical/ward pharmacist…… 4
		Physician…… 5
		Nurse…… 6
		Other healthcare professional – please specify…… 7
4	Are you directly involved in medicine procurement in your hospital?	Yes……1
		No…… 2
5	Level of care in your hospital	Specialised/tertiary/regional hospital…… 1
		District/secondaryhospital……2
		First level hospital/community hospital/primary care Hospital……3

Section B: Antibiotic shortages

Number	Questions and filters	Participant's response and coding categories
1	At which level is medicine tendering for public hospitals carried out in your country?	Nationally…… 1 Provincially…… 2 At hospital level…… 3 Both nationally and at the hospital level…… 4 Both provincially/regionally and at the hospital level……5
2	Please mark all criteria relevant to the medicine procurement and tendering procedure in your hospital/country	Assessment of suppliers (e.g. assessment of performance in a previous tender; assessment of the medium time to supply after the order) ……1 Lowest price of a medicine…… 2 Quality standards (e.g. included in good manufacturing practice (GMP), or legislation or other)…3 Storage capacity of a wholesaler/provider……4 The number of active pharmaceutical ingredient (API) suppliers (refers to a manufacturer or pharmaceutical company) …… 5
3	Are shortages of antibiotics a current problem in the hospital you are working with respect to delivering the best care to patients and/or operating the hospital pharmacy?	Yes…… 1 No…… 2
4	In your experience, in 2024 how many times had you experienced a shortage of antibiotics in your hospital?	1–3 times……1 4–6 times……2 7–10 times……3 More than 10 times……4
5	In 2024 how many times did you experience a shortage of essential antibiotics?	1–3 times……1 4–6 times…… 2 7–10 times…… 3 More than 10 times……4
6	In your experience, what was the typical duration of antibiotic shortages in 2024?	>1 week…… 1 1–2 weeks …… 2 3–4 weeks…… 3 1–2 months…… 4 More than 2 months…… 5 I don't know……6
7	Please list which essential antibiotics where there were shortages in your hospital in 2024	Free text
8	What do you see as the cause of antibiotic shortages in your hospital/country? (tick all that apply)	Poor planning/forecasting……1 Financial/funding constraints…… 2 Global shortage of an active pharmaceutical ingredient (API)……3 Increasing demand for the specific antibiotic…… 4 Manufacturing problems…… 5 Legislative obstacles…… 6 Price of an antibiotic……7 Procurement/tendering challenges……8 Quality problems…… 9 Stock-piling of antibiotics……10 Supply chain problems……11 Lack of storage facilities for antibiotics…… 12 Other (please specify)…… 13
9	Do you have a list of essential antibiotics which should never be in short supply in your hospital?	Yes……1 No…… 2 I don't know…… 3
10	(if answer to Q9 is Yes) Please indicate who was responsible for the creation of the list of essential antibiotics: [tick all that apply] If the answer to Q9 is No or Don't know select not applicable	Hospital…… 1 Regional/local healthcare setting committee……2 National health authority…… 3 Other (please specify) …… 4 Not applicable…… 4

Section C: Antibiotic shortages management		
Number	**Questions and filters**	**Participant's response coding categories**
11	Do you use an electronic pharmaceutical management system (e.g. RxSolution) to manage inventory, purchase orders, dispense antibiotics and monitor stock availability?	Yes……1 No…… 2 Not applicable…… 3
12	Is the electronic pharmaceutical management system automatically fed with information regarding ongoing antibiotic shortages and potential alternatives in your hospital?	Yes…… 1 No…… 2 Not applicable…… 3
13	Is the reporting of medicine shortages mandatory in your country?	Yes…… 1 No…… 2 I don't know…… 3
14	If answer to Q13 is Yes - Do you have a national reporting system on medicine shortages? If no or don't know select not applicable.	Yes……1 No…… 2 I don't know……3 Not applicable……4
15	If answer to Q13 is Yes - Name the reporting system or database for reporting medicine shortages in your hospital/country. If no, write not applicable	Free text
16	Who manages the medicine availability/ shortage reporting system in your country? (tick all that apply)	Healthcare professionals……1 Medicines agency……2 Ministry of health……3 Patient associations…… 4 University/academic/scientific associations……5 Other (please specify)……6 Not applicable …… 7
17	Do you get feedback from an organisation/ entity in charge of the reporting system, when you report a shortage of specific antibiotics?	Yes …… 1 No……2 I don't know……3
18	If answer to Q13 is No - Please briefly describe the reporting procedure for medicine shortages at your facility and if possible, in your country. If don't know write not applicable	Free text
19	Do manufacturers/pharmaceutical companies communicate shortages of antibiotics independently of or based on legal obligations?	Independently……1 Based on legal obligations……2 I don't know…… 3
20	(for those that ticked the first two options of Q19) How often do manufacturers/ pharmaceutical companies communicate shortages? If ticked 'don't know' select not applicable	Always……1 Rarely…… 2 Never ……3 Not applicable…… 3
21	Do you have a medicine shortages task force? (tick all that apply)	Yes, in my hospital comprised of hospital pharmacists……1 Yes, in my hospital. Multiple different professionals are involved……2 Yes, at provincial/regional level comprised of hospital pharmacists……3 Yes, at provincial level/regional level. Multiple different professionals are involved…… 4 Yes, at national level comprised of hospital pharmacists…… 5 Yes, at national multiple different professionals are involved…… 6 No…… 7 I don't know…… 8 Other (please specify) …… 9
22	How do you communicate information on shortages/alternatives with other healthcare professionals	By email…… 1 By phone……2 By WhatsApp/social media…… 3 Via face-to-face meetings…… 4 Via print material such as bulletins, letters, newsletters ……5 Via the Pharmaceutical and Therapeutics Committee…… 6 Other (please specify):……7

Contd...

Section C: Contd...

Number	Questions and filters	Participant's response coding categories
23	Do you have a protocol/policy on therapeutic substitutions due to antibiotic shortages in your hospital?	Yes……1 No…… 2 I don't know……3
24	(if answer to Q23 is Yes) Who is responsible for the development of therapeutic substitution policies at your facility?	Pharmaceutical and Therapeutics Committee……1 Pharmacists……2 Physicians…… 3 Other (please specify):…… 4
25	(if answer to Q23 is Yes) Describe the substitution procedure when there is a shortage of a particular requested antibiotic at your hospital facility. If answer to Q23 is don't know, write not applicable	Free text
26	Did you have to implement clinical changes in order to manage antibiotic shortages?	Yes……1 No…… 2 I don't know…… 3
27	(if answer to Q26 is Yes) Please select all the clinical changes that you deem appropriate and/or use regularly. (Definition: Clinical change represents a change of treatment, treatment protocol or procedure due to medicine shortages.) If no/don't know, select not applicable	Switching to alternative medicine that might not be as effective as a medicine affected by a shortage or have additional side effects……1 Converting from intravenous to the oral form of a medicine……2 changing administration protocols…… 3 dispensed second/third/fourth generation antibiotics…… 4 dispensed more expensive alternatives……5 referred the patient to a private institution……6 sent the patient away with no medication……7 Other (please specify) ……8 Not applicable…… 9
28	Have you implemented operational changes in order to manage antibiotic shortages in your hospital? (Definition: Operational change represents a change in working processes targeting the provision of healthcare services.)	Yes…… 1 No……2 I don't know…… 3
29	(if answer to Q28 is Yes) Please select all the operational changes you deem appropriate and/or use regularly If no/don't know, select not applicable	Changing medicinal products stocked for procedures and emergencies……1 Purchasing medicine's vial sizes, pack sizes or concentrations not routinely stocked……2 Centralising inventory management……3 Other (please specify)……4 Not applicable…… 5
30	What do you do when antibiotic shortages occur in your hospital	Manage it and don't mention it to anyone…… 1 Overcome a shortage and inform only the facility manager…… 2 Overcome a shortage and inform all healthcare professionals (HCPs)… …… 3 Overcome a shortage and inform both HCPs and patients of the outcome of shortages management……4 Manage only essential medicine shortages……5 Ignore a shortage and do nothing……6 Other (please specify) ……7
31	How would you rank the following solutions? (1=not useful to 5=very useful)	Improved enforcing the mandatory early notification of a medicine shortage …… 1 Evoking appropriate staffing levels in order to lower the impact that medicine shortages currently have on the overall patient services……2 Mandating improved communication among all stakeholders (manufacturers, parallel traders, wholesalers and HCPs) ……3
32	Do you have another solution that is currently being applied in your hospital/your country that could help alleviate the problem of antibiotic shortages? If yes – please specify. If not write not applicable	Free text response

Section D: Impact of antibiotic shortages on patients

Number	Questions and filters	Participant's response and coding categories
33	Did the antibiotic shortage(s) you experienced in 2024 have an impact on patient care in your hospital?	Yes…… 1 No…… 2 I don't know…… 3
34	(if answer to Q33 is Yes) Please choose the type of impact antibiotic shortages had on patient care in your hospital If no/don't know, select not applicable	Adverse events (please specify) …… 1 Cancellation of care (abandoned or terminated) …… 2 Death…… 3 Delays in care/therapy in the disease pathway……4 Increased length of stay in the hospital…… 5 Higher hospital admission rates……6 Increased monitoring of a patient……7 Medication error…… 8 Readmission due to treatment failure……9 Suboptimal treatment/inferior efficacy……10 Transfer of a patient to facility where a medicine can be provided ……11 Treatment failure…… 12 No access to this data……13 Other (please specify)……14 Not applicable……15
35	(if answer to Q33 is Yes) Please grade the severity of shortages: If no/don't know, select not applicable	No impact…… 1 Mild impact…… 2 Moderate impact…… 3 Severe impact…… 4 Not applicable…… 5

Section E: Antimicrobial stewardship and antibiotic shortages

Number	Questions and filters	Participant's response and coding categories
36	Do you have any antimicrobial stewardship programs in your hospital?	Yes…… 1 No…… 2
37	Have you ever received training on antimicrobial stewardship?	Yes…… 1 No…… 2
38	(If the answer is yes for Q37) When did you last receive any training for antimicrobial stewardship? If no, select not applicable	Within the last 6 months…… 1 6–12 months ago…… 2 1–2 years ago …… 3 More than 2 years ago…… 4 I don't remember…… 5 Not applicable…… 6
39	Do you see antimicrobial stewardship programs as a strategy to address antibiotic shortages in your hospital?	Yes…… 1 No…… 2

Thank you for your valuable time and participation

Please click on the 'Submit' button when you are satisfied with your response.

SUBMIT