Antimicrobial Stewardship Program Implementation, Perceptions, and Barriers in Zambia: A Cross-Sectional Study Among Healthcare Professionals

Steward Mudenda [1,2,*], Joseph Yamweka Chizimu [1,*], Victor Daka [3], Jimmy Hangoma [4], Kelvin Mwangilwa [1], Priscilla Gardner [1], Chikwanda Chileshe [5], Taona Sinyawa [6,7], Zoran Muhimba [1,8], Charles Chileshe [1], Sandra Diana Mwadetsa [9], Shikanga O-Tipo [9], Duncan Chanda [8], Maisa Kasanga [1,8], Geoffrey Mainda [10], Webrod Mufwambi [2], Samson Mukale [1], Andrew Bambala [8], Fusya Goma [6], Aubrey Chichonyi Kalungia [2], Yasuhiko Suzuki [11], Brian Godman [12,13,14], John Bwalya Muma [7] and Roma Chilengi [1]

1 Zambia National Public Health Institute, Antimicrobial Resistance Coordinating Committee, Lusaka 10101, Zambia; mwangilwakelvin@yahoo.com (K.M.); priscillagardner82@gmail.com (P.G.); zmuhimba@yahoo.com (Z.M.); chichalesi2@gmail.com (C.C.); kasangaanita@gmail.com (M.K.); mukalesamson14@gmail.com (S.M.); chilengir@yahoo.com (R.C.)
2 Department of Pharmacy, School of Health Sciences, University of Zambia, Lusaka 10101, Zambia; webrod.mufwambi@unza.ac.zm (W.M.); ckalungia@unza.ac.zm (A.C.K.)
3 Public Health Department, School of Medicine, Copperbelt University, Ndola 10101, Zambia; dakavictorm@gmail.com
4 Department of Pharmacy, School of Health Sciences, Levy Mwanawasa Medical University, Lusaka 10101, Zambia; jimmy.hangoma@lmmu.ac.zm
5 Department of Biomedical Sciences, School of Veterinary Medicine, University of Zambia, Lusaka 10101, Zambia; chikchile@gmail.com
6 Ministry of Fisheries and Livestock, Lusaka 10101, Zambia; taonasinyawa@gmail.com (T.S.); fusya.goma@mfl.gov.zm (F.G.)
7 Department of Disease Control, School of Veterinary Medicine, University of Zambia, Lusaka 10101, Zambia; jmuma@unza.zm
8 Department of Infectious Diseases, University Teaching Hospital, Lusaka 10101, Zambia; duncanchanda@gmail.com (D.C.)
9 Word Health Organization, Lusaka 10101, Zambia; mwadetsas@who.int (S.D.M.); otipos@who.int (S.O.-T.)
10 Food and Agriculture Organization, Lusaka 10101, Zambia; geoffrey.mainda@fao.org
11 Division of Research Support, Institute for Vaccine Research and Development, Hokkaido University, Sapporo 001-0021, Japan; suzuki@czc.hokudai.ac.jp
12 Department of Public Health Pharmacy and Management, School of Pharmacy, Sefako Makgatho Health Sciences University, Garankuwa, Pretoria 0208, South Africa; brian.godman@smu.ac.za
13 Department of Pharmacoepidemiology, Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow G4 0RE, UK
14 Antibiotic Policy Group, Institute for Infection and Immunity, City St. George's, University of London, London SW17 0RE, UK
* Correspondence: steward.mudenda@unza.ac.zm or steward.mudenda@unza.zm (S.M.); chizimuyjoseph@yahoo.com (J.Y.C.); Tel.: +260-977549974 (S.M.); +260-970449484 (J.Y.C.)

Abstract

Background/Objectives: Antimicrobial stewardship programs (ASPs) play a vital role in combating antimicrobial resistance (AMR). However, their implementation in Zambia remains variable despite some notable progress. This study assessed healthcare professionals' awareness of the Multisectoral National Action Plan (NAP) on AMR, alongside their perceptions, barriers, and implementation practices related to ASPs. **Methods**: A cross-sectional survey conducted between August and December 2024 included 364 healthcare professionals (HCPs) in 58 randomly selected public healthcare facilities in Zambia. Data were analysed using IBM SPSS 25.0. **Results**: Findings revealed that while 75.3% of respondents were aware of the Zambian NAP on AMS, only 68.1% of the respondents reported that their hospitals had established AMS committees. Conversely only 41.2% of

the respondents stated that their hospitals possessed hospital-specific treatment guidelines. Encouragingly, 97.5% believed ASPs could enhance clinical outcomes and reduce AMR. Key barriers included limited funding (75.9%), inadequate IT infrastructure (64.1%), limited access to essential data (64%), and healthcare workforce shortages (53.8%). **Conclusions**: Whilst HCPs in Zambia demonstrated high awareness of the NAP and supported ASP implementation, systemic challenges hindered their consistent execution across health facilities. Gaps in treatment guideline development, AMR data usage, and the integration of antimicrobial susceptibility recording systems into clinical activities must be addressed to strengthen ASP efforts nationwide.

Keywords: antimicrobial stewardship; antimicrobial resistance; healthcare professionals; barriers; implementation; perceptions; Zambia

1. Introduction

Antimicrobial resistance (AMR) has emerged as one of the most pressing global public health challenges of the 21st century [1–3]. AMR compromises the effectiveness of antimicrobials, increasing morbidity and mortality as well as imposing significant economic strain on healthcare systems [1,4–7]. The persistent misuse and overuse of antimicrobials across the human, animal, and agriculture sectors continue to accelerate the emergence and spread of resistant pathogens [8–13], with AMR increasingly seen as the next pandemic unless multiple coordinated activities are undertaken [3,4,14–16]. This is particularly important in low- and middle-income countries (LMICs), including African countries, where AMR rates are high and growing [1,15,17]. Zambia is no exception, with currently high rates of AMR, including for commonly used antibiotics [10,18,19].

In response to this escalating threat, several global, regional, and national initiatives have been launched. The World Health Organization (WHO) introduced the Global Action Plan on AMR in 2015, urging member states to develop their national action plans (NAPs) and implement sustainable interventions to improve antimicrobial use, including antimicrobial stewardship programs (ASPs) [20,21]. However, concerns have been raised regarding the implementation of NAPs in LMICs, including those in Africa, due to personnel and resource issues, as well as underdeveloped healthcare infrastructures, which include a lack of laboratory capacity for routine analysis of local and regional resistance patterns [21–27].

ASPs refer to coordinated interventions designed to promote the appropriate use of antimicrobials, improve patient outcomes, reduce AMR, and decrease the spread of infections caused by multidrug-resistant organisms [28–33]. For ASPs to be effective, a collaborative, multidisciplinary approach is essential, engaging a range of professionals, including physicians, pharmacists, nurses, biomedical scientists, and infection prevention specialists [34–36]. The success of ASPs is closely underpinned by their integration into institutional structures, reinforced through comprehensive policies, robust standardised treatment guidelines, surveillance and diagnostic systems, and continuous professional capacity-building initiatives [37–39]. Recently, there have been concerns to promote the WHO's Access, Watch, and Reserve (AWaRe) framework, which guides rational antibiotic use, with targets now requiring at least 70% of prescriptions to come from Access antibiotics [40–43]. Despite the 2022 AWaRe guidance book and growing integration of AWaRe-based quality targets into ASPs, excessive use of Watch and Reserve antibiotics continues to drive AMR globally, contributing to an estimated 659,000 child deaths in Africa [41,44–47]. This challenge is evident in many LMICs, including Zambia, where high

use of Watch group antibiotics persists despite some facilities showing better prescribing practices [46,48–54].

Implementing AMS programs in LMICs, including Zambia, has been a challenge due to systemic limitations, including underdeveloped healthcare infrastructure, constrained financial resources, limited laboratory capacity, and shortages of key trained personnel [10,17,22,55]. There have also been concerns with limited knowledge and activities regarding antibiotics, AMR and ASPs among prescribers across the sectors in LMICs, including Zambia [56,57]. However, this is changing with multiple ASPs now being undertaken across Africa [22,33,58,59]. Zambia launched its ten-year NAP on AMR (2017–2027) in 2017, setting forth strategic priorities that include strengthening knowledge through surveillance and research, optimising antimicrobial use, and improving awareness and understanding of AMR across sectors [60].

Central to the success of ASPs are the commitment and knowledge of healthcare professionals (HCPs) [61–63], whose knowledge, attitudes, and practices significantly influence antimicrobial prescribing patterns, infection control strategies, and the implementation of AMS interventions [64,65]. Therefore, evaluating HCPs' awareness of AMS principles, understanding the barriers they encounter in implementing ASPs, and identifying institutional support gaps are critical steps towards designing context-specific interventions to improve the future use of antibiotics in Zambia. We are aware that some studies have been undertaken in Zambia to assess current knowledge and attitudes towards antimicrobial use (AMU), AMR and ASPs [64,66]. However, given the previous concerns of gaps in ASP awareness and implementation in some studies in Zambia and the ongoing goals of the Zambian NAP to reduce AMR, we believed it was imperative to increase our understanding of institutional preparedness for ASP implementation in Zambia, including revealing any vital evidence gaps that impede effective policy translation. Given this, this study assessed the level of awareness of the Zambian NAP on AMR, perceptions, and barriers to ASP implementation among HCPs in Zambia. By assessing HCPs' perspectives and current institutional practices, the study sought to generate insights that inform capacity-building initiatives, support policy implementation, and reinforce antimicrobial stewardship (AMS) efforts in Zambia.

2. Results

A total of 364 HCPs participated in the study. The majority were clinicians (27.5%), nursing professionals (26.6%), and pharmacy professionals (22.0%) (Table 1). Most respondents were aged 25–34 years (54.4%), with female respondents slightly outnumbering males (51.9%). In terms of professional experience, 66.5% had over five years of experience in their current specialty, indicating a predominantly experienced and mid-career workforce (Table 1).

Most of the respondents (75.3%) were aware of the Zambian NAP on AMR, providing a strong foundation for its effectiveness. The study also found that 68.1% of the respondents reported that their hospitals had an AMS committee, and only 66.2% stated that their hospitals had a policy for documenting antibiotic prescriptions, indicating areas for improvement. Additionally, only 41.2% of the respondents stated that their hospitals had hospital-specific treatment guidelines (Table 2). Notably, a considerable proportion of respondents were uncertain about the existence of these ASP components, suggesting potential gaps in communication or documentation.

Table 1. Healthcare Professionals Demographic Characteristics (N = 364).

Category	Subcategory	Frequency	Percent
Distribution of HCPs	Clinicians	100	27.5
	Pharmacy Professionals	80	22.0
	Nursing Professionals	97	26.6
	Biomedical Science Professionals	49	13.5
	Public & Environmental Health	20	5.5
	Microbiologists	6	1.6
	Health Information/Administration Staff	5	1.4
	Other Allied Health Professionals	7	1.9
	Total	364	100.0
Age (Years)	18–24	3	0.8
	25–34	198	54.4
	35–44	99	27.2
	45–54	56	15.4
	55 and above	8	2.2
	Total	364	100.0
Gender	Male	175	48.1
	Female	189	51.9
	Total	364	100.0
Experience in Current Specialty	Less than 1 year	15	4.1
	1–5 years	107	29.4
	Above 5 years	242	66.5
	Total	364	100.0
Hospital Classification	Secondary	46	79.3
	Tertiary	12	20.7
	Total	58	100
HCPs by Hospital	Secondary	245	67.3
	Tertiary	119	32.7
	Total	364	100

Table 2. Implementation of Antimicrobial Stewardship Program Components in Zambian Hospitals (N = 364).

ASP Component	Yes n (%)	No n (%)	Not Sure n (%)
Awareness of National Action Plan (2017–2027)	274 (75.3)	90 (24.7)	0.0
The hospital has an AMS Committee	248 (68.1)	74 (20.3)	42 (11.6)
Policy on documenting dose, duration, and indication for antibiotics	241 (66.2)	63 (17.3)	60 (16.5)
Hospital-specific treatment guidelines based on national/local susceptibility	150 (41.2)	134 (36.8)	80 (22.0)
Use of AMR surveillance reports	125 (34.3)	112 (30.8)	127 (34.9)
Software to record antimicrobial susceptibility results	104 (28.6)	137 (37.6)	123 (33.8)
Availability of antimicrobial use reports	139 (38.2)	103 (28.3)	122 (33.5)
Access to evidence-based medicine during care	212 (58.2)	73 (20.1)	79 (21.7)
Education for prescribers on optimal prescribing and resistance	241 (66.2)	71 (19.5)	52 (14.3)

Table 3 summarises the responses of HCPs (N = 364) to statements regarding the perceived importance of AMS activities. Regarding whether AMS activities would improve patients' clinical outcomes, the vast majority of respondents (97.5%) either strongly agreed (80.2%) or agreed (17.3%) with this statement. This highlights a high level of awareness among HCPs regarding the clinical benefits of ASPs. Similarly, 97.6% of respondents agreed or strongly agreed that ASPs are a vital strategy to combat AMR. A combined

97% agreement rate indicates that most HCPs believed implementing ASPs could reduce unnecessary healthcare expenditure by minimising ineffective treatments and resistance-related complications.

Table 3. Perceptions of Healthcare Professionals on AMS (N = 364).

Perception Statement	Response Option	Frequency	%
AMS will improve patients' clinical outcomes	Strongly agree	292	80.2
	Agree	63	17.3
	Neutral	8	2.2
	Strongly disagree	1	0.3
AMS will reduce antimicrobial resistance	Strongly agree	294	80.8
	Agree	61	16.8
	Neutral	8	2.2
	Disagree	1	0.3
AMS improves the cost-effectiveness of healthcare	Strongly agree	267	73.4
	Agree	86	23.6
	Neutral	10	2.7
	Disagree	1	0.3
AMS improves collaboration among healthcare providers	Strongly agree	245	67.3
	Agree	100	27.5
	Neutral	19	5.2

Overall, the respondents significantly agreed ($p < 0.001$) with all the perception statements, indicating they viewed AMS activities as positively impacting the various aspects of AMR.

This study found that the main barriers to implementation of ASPs in Zambian hospitals included a lack of funding, inadequate IT support, limited resources for data collection, shortages of HCPs, and a lack of awareness of ASP by hospital administration (Table 4).

Table 4. Reported Barriers to AMS Program Implementation in Zambian Hospitals (N = 364).

Barrier	Response	Frequency	(%)
Lack of sufficient healthcare providers	Strongly agree	75	20.6%
	Agree	121	33.2%
	Neutral	78	21.4%
	Disagree	69	19.0%
	Strongly disagree	21	5.8%
Lack of funding	Strongly agree	140	38.5%
	Agree	136	37.4%
	Neutral	54	14.8%
	Disagree	31	8.5%
	Strongly disagree	3	0.8%
Hospital administration is unaware of AMS programs	Strongly agree	37	10.2%
	Agree	46	12.6%
	Neutral	63	17.3%
	Disagree	137	37.6%
	Strongly disagree	81	22.3%

Table 4. *Cont.*

Barrier	Response	Frequency	(%)
Prescribers are unaware of AMS programs.	Strongly agree	44	12.1%
	Agree	77	21.2%
	Neutral	73	20.1%
	Disagree	120	33.0%
	Strongly disagree	50	13.7%
Opposition from prescribers	Strongly agree	36	9.9%
	Agree	85	23.4%
	Neutral	117	32.1%
	Disagree	100	27.5%
	Strongly disagree	26	7.1%
Lack of IT support	Strongly agree	65	17.9%
	Agree	168	46.2%
	Neutral	71	19.5%
	Disagree	47	12.9%
	Strongly disagree	13	3.6%
Lack of resources to get the needed data	Strongly agree	84	23.1%
	Agree	149	40.9%
	Neutral	71	19.5%
	Disagree	45	12.4%
	Strongly disagree	15	4.1%

3. Discussion

This study aimed to assess the awareness of the Zambia NAP on AMR, perceptions, barriers, and implementation of ASP initiatives among HCPs in hospitals in Zambia. Overall, just over two-thirds of hospitals had an AMS committee, even though 75.3% of the respondents were familiar with Zambia's NAP on AMR. Furthermore, the study found that 68.1% of the respondents reported that their facilities had AMS committees, and only 34.3% of respondents stated that their hospitals utilised AMR monitoring data to guide antibiotic choices. This is a concern with the lack of AMR surveillance limiting public health action and interventions. However, the findings in Zambia are similar to other LMICs, including other African countries, where comprehensive population-based surveillance of AMR, alongside data entry, was lacking and largely fragmented [67,68]. In addition to the observed challenges, we found a lack of software for recording antimicrobial susceptibility results as reported by 28.6% of the respondents, underscoring significant gaps in AMS infrastructure. These findings suggest that while awareness exists, translation into consistent practice and policy adherence remains a challenge. Previous findings in Zambia have also reported inadequate laboratory capacity to conduct microbiological tests and surveillance of AMR [69].

Despite these challenges, nearly all respondents agreed that ASPs would improve clinical outcomes and help reduce AMR. However, the main identified barriers to ASP implementation included limited funding, reported by approximately three-quarters of respondents; inadequate IT infrastructure, noted by nearly two-thirds; and restricted access to critical data, cited by a similar proportion. These findings suggest that while awareness exists, translation into consistent practice and policy adherence remains a challenge. Previous studies conducted in Zambia have also reported inadequate laboratory capacity to conduct microbiological tests and surveillance of AMR [69]. Insufficient funding continues to be a major barrier to the implementation of the ASPs [70]. A systematic analysis of AMR in the WHO African region noted that population-based surveillance is often absent, with data scarce due to inadequate laboratory infrastructure and fragmented reporting

systems [17]. These findings underscore systemic gaps in laboratory infrastructure, digital health capacity, and human resources, which must be addressed across Africa, including Zambia, going forward to enable real-time AMR monitoring to inform antimicrobial policy and address rising AMR rates.

Additionally, just over half of the respondents pointed to a shortage of HCPs as a significant constraint to implementing ASPs, which is similar to other countries [39,55,71–73]. Alongside this, the lack of dedicated multidisciplinary ASP teams is among the main barriers to implementation of ASPs in hospitals [71,72,74]. Having said this, the presence of AMS committees and education programs in many health facilities as reported by the majority of HCPs indicates that foundational ASP components were in place in hospitals in Zambia at the time of the survey, similar to previous evidence [64]. This is critical in ensuring the establishment of functional ASPs in hospitals [35,75], with functional AMS committees and ASPs key to promoting the rational use of antibiotics in hospitals to meet UN GA targets [28,30,39,43,61,76,77].

Whilst encouraging, the overall awareness of the NAP on AMR was high among participating HCPs in our study, critical gaps remain in the operationalisation of ASPs among health facilities in Zambia, as reported earlier [78]. This pattern reflects similar challenges reported in other LMICs, where ASP implementation often lags behind policy directives due to systemic and infrastructural limitations of the NAP on AMR [62,72,78–83]. The disconnection between policy and practice could reflect a gap in the interpretation of the NAP on AMR by HCPs in previous studies [23,84].

In this study, another identified concern was the limited availability of hospital-specific STGs. This was built on a similar study in Zambia conducted among district hospitals, which found that while STGs were present in some facilities, overall compliance with the STGs ranged from 0% to 57% [53]. In addition, a study conducted in the African Union found that only 20 of the 55 countries in the Union had STGs [85]. The limited availability and poor use of STGs have far-reaching public health implications. The recent availability of the WHO AWaRe guidance covering the treatment of 35 infectious diseases across all sectors provides a robust platform going forward to address concerns with the lack of STGs [41,45,86]. Pertinent guidelines can subsequently be amended based on local resistance patterns. The next stages involved their active dissemination and monitoring. Concurrent with this, hospital HCPs must be trained not only on AMS principles but also on the practical application of these guidelines in clinical settings [65].

Encouragingly, HCPs in this study strongly believed in the effectiveness of ASPs in improving clinical outcomes (97.5%), reducing resistance (97.6%), and enhancing cost-effectiveness (97%), which was an improvement over previous studies in Zambia [73]. These high perception scores are consistent with findings from similar surveys in Kenya, Uganda and Nigeria, where HCPs recognised the value of AMS; however, they cited operational and contextual challenges as barriers to full implementation [87–89]. In addition, in this study, only a relatively small proportion of respondents viewed a lack of awareness among prescribers or opposition from them as barriers to ASPs, suggesting that the healthcare workforce in Zambia is receptive to AMS principles. These barriers have been reported in previous studies and imped progress made in addressing AMR [73,90,91]. This presents an opportunity to leverage the existing support to ASPs among HCPs through targeted investments in infrastructure, leadership, and accountability mechanisms.

In this study, some key barriers to implementing ASPs included inadequate funding, lack of IT support, limited access to data, shortage of HCPs, and lack of awareness of ASPs by administration staff. These barriers reflect well-documented constraints in LMICs, where AMS implementation is often hampered by weak laboratory capacity, inadequate leadership support, lack of electronic health records, and limited financial and human

resources [22,57,62,81,92–94]. The absence of essential AMS enablers such as reliable microbiological diagnostics and routine antimicrobial use audits compromises the ability to monitor resistance patterns and optimise prescribing practices [71,95]. This further complicates the management of patients who may need timely interventions. Similarly, a study conducted in Saudi Arabia found that the major barriers to implementation of ASPs were a lack of internal policy/guidelines and specialised AMS information resources, inadequate administrative awareness of ASPs, lack of AMS personnel, limited training opportunities, time limitation, lack of confidence, and limited funding [73]. Consequently, there is a need to strengthen AMS interventions and other strategies to combat AMR in Zambia and across LMICs [33,38,75,96–99].

We are aware that this study has some limitations. First, the use of convenience sampling limits the generalizability of the findings to all HCPs in Zambia. Although facilities were randomly selected, recruitment of participants within facilities was based on convenience sampling, which may introduce selection bias and affect representativeness across professional groups. Second, the cross-sectional design captures responses at a single point in time and may not reflect ongoing changes in AMS awareness and implementation. Third, the study relied on self-reported data, which is subject to social desirability and recall bias. Moreover, the study did not assess actual AMS practices or antimicrobial prescribing patterns, which would provide a more comprehensive understanding of stewardship performance. Fourth, while the survey covered multiple cadres and facilities across Zambia, the inclusion of only public healthcare facilities limits the generalizability of findings to private sector and community-based settings. Fifth, the study did not directly measure antibiotic prescribing practices or link responses to microbiological or pharmacy data, which restricts the ability to validate reported stewardship activities. Sixth, variations in ASP implementation between rural and urban healthcare settings were not accounted for during the analysis. Lastly, there was an uneven distribution of respondents across cadres (clinicians, nurses, pharmacists, biomedical scientists), as well as possible over-representation of urban facilities compared to rural ones, limiting generalizability.

Despite these limitations, we believe the study provides valuable insights into ASP implementations in health facilities in Zambia. Inclusion of a wide range of HCPs, including clinicians, nurses, pharmacists, biomedical scientists, public health officers, and allied health workers, offered diverse perspectives on AMS implementation. Additionally, addressing AMR and AMS aligns with national and global health priorities, particularly the WHO GAP and Zambia's NAP on AMR. Further, the study provides current, context-specific evidence on the awareness, implementation status, and barriers of AMS in Zambia, filling a critical knowledge gap. Furthermore, the research highlights systemic and operational barriers such as a lack of funding, inadequate IT infrastructure, and data limitations, which are essential for designing targeted interventions. A sample of 364 HCPs strengthens the reliability and generalizability of the findings within the Zambian context. The study also revealed strong healthcare professional support for AMS, providing a solid foundation for advocacy, training, and policy development. The findings directly inform Zambia's AMR policy landscape by identifying implementation gaps and opportunities for strengthening institutional ASP capacity. Finally, the study provided valuable baseline data that can be used to monitor trends in ASP implementation and effectiveness over time.

The policy implications and recommendations of this study are provided in Table 5. This study shows that while awareness of ASPs in Zambia is high among HCPs, implementation is limited. Policymakers should strengthen enforcement of the Zambia NAP on AMR, increase funding, improve IT and laboratory capacity, and align antibiotic use with WHO AWaRe targets. At the practice level, hospitals should develop and adapt treatment guidelines, promote inter-professional collaboration, and conduct regular audits

to ensure rational antibiotic prescribing. Addressing workforce shortages and leveraging HCPs' positive perceptions of ASPs will be key to strengthening stewardship and reducing inappropriate antibiotic use.

Table 5. Policy Implications and Recommendations Based on the Study Findings.

Key Finding	Policy Implications	Practice Recommendations
• High awareness of ASPs among HCPs, but poor implementation	• Incorporate AMS into national health priorities and policies; strengthen enforcement of the Zambia National Action Plan (NAP) on AMR	• Enhance training and continuous professional development of HCPs on ASP implementation
• Limited hospital-specific treatment guidelines and surveillance data use	• Develop, update, and enforce standardised treatment guidelines (STGs) informed by local AMR data	• Support hospital-level AMS committees to adapt STGs for local use
• Major barriers: lack of funding, IT support, and resources for data	• Increase dedicated government and donor funding for AMS activities and infrastructure	• Invest in laboratory and IT systems for AMR data collection and reporting
• Workforce shortages	• Advocate for recruitment and retention policies to expand health workforce capacity.	• Train multidisciplinary teams to implement AMS at the facility level
• Positive perceptions of ASP benefits among HCPs	• Leverage HCPs' support to integrate AMS into routine practice	• Promote inter-professional collaboration and mentorship in AMS activities
• High use of Watch antibiotics and gaps in adherence to AWaRe targets	• Align procurement and prescribing policies with WHO AWaRe targets ($\geq$70% Access group use)	• Conduct regular audits and feedback to ensure rational antibiotic prescribing

4. Materials and Methods

4.1. Study Design and Setting

This study employed a cross-sectional design conducted between August 2024 and December 2024 in Zambia. The survey targeted HCPs in facilities that included primary, secondary and tertiary care settings. Only HCPs registered with the Health Professions Council of Zambia and the Nursing Council of Zambia were eligible to participate in the study. The study aimed to assess HCPs' awareness of the Zambian NAP on AMR, perceptions and barriers to the implementation of ASPs in Zambia.

4.2. Study Population and Sampling

The study population comprised registered HCPs in Zambia, including medical doctors, clinical officers, nurses, pharmacy personnel (pharmacists & pharmacy technologists), biomedical scientists, public health officers, and other allied health professionals. A stratified sampling approach was subsequently employed. Firstly, a list of all public health facilities in the country was obtained from the Ministry of Health to serve as the sampling frame. Of these facilities, 100 were selected as sites to establish and implement ASPs across the country. Hence, a random selection of the facilities was made, ensuring regional representation. Within each selected facility, convenient sampling was undertaken to select

respondents across different healthcare professions, including medical doctors, clinical officers, nurses, pharmacy personnel, biomedical scientists, public health officers, and those in administration. The respondents were recruited conveniently based on their professional role and availability during the survey period. From a total of 100 facilities where the Zambia Antimicrobial Resistance Coordinating Committee (AMRCC) planned to instigate ASPs, a total of 58 (46 secondary and 12 tertiary hospitals) hospitals were randomly selected to reduce bias. The stratified facilities included secondary and tertiary hospitals, which were selected for the initiation of ASPs. The random approach ensured representation from diverse facilities and geographic regions.

4.3. Inclusion and Exclusion Criteria

Eligible respondents were those directly or indirectly involved in antimicrobial prescribing, dispensing, administration, or monitoring and who provided informed consent to participate. Respondents were excluded if they did not provide informed consent or withdrew from the study before completion.

4.4. Data Collection Tool and Procedure

Data were collected using a structured, self-administered questionnaire developed based on a similar previous study among HCPs [100]. The questionnaire was designed in English, the official language used in healthcare settings in Zambia. It consisted of five sections, including demographics (age, gender, profession and years of experience), awareness of the NAP on AMR and ASPs, implementation of ASP components, perceptions of the importance and effectiveness of ASPs and the perceived barriers to ASP implementation (See Supplementary Materials).

The data collection tool was validated to ensure clarity, consistency, and face validity, with input from public health experts from the Zambia AMRCC and academia before the study. This was followed by a pilot study using a sample of 20 HCPs. Feedback from the pilot study was used to refine the questionnaire before full-scale deployment, but did not form the final analysis of the study.

Questionnaires were administered in person by trained research assistants at each public health facility, ensuring standardised delivery and data collection procedures. Respondents completed the questionnaires anonymously and returned them in sealed envelopes to maintain confidentiality.

4.5. Data Management and Statistical Analysis

The completed questionnaires were checked for completeness and consistency before data entry into Microsoft Excel version 2013 and then exported to IBM SPSS Statistics (Version 25.0; IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics were used to summarise respondents' demographic characteristics and the distribution of responses across awareness, implementation, perception, and barrier domains. Differences in responses were assessed with the use of the chi-square. Statistical significance was set at $p < 0.05$, and findings were presented using tables and charts.

5. Conclusions

This study highlights that although HCPs in Zambia demonstrated strong awareness of the NAP on AMR and ASP activities, and appreciate their role in combating AMR, notable deficiencies persist in the practical implementation of ASPs within hospitals in Zambia. Key structural barriers, including insufficient funding, limited IT infrastructure, and lack of access to surveillance data, significantly compromise the effectiveness of AMS strategies in Zambia. Targeted investment in digital health programs, reinforcing policy

frameworks, and delivery of sustained capacity-building and education initiatives will be key to bridging these gaps in Zambia and similar LMIC settings.

Abbreviations

The following abbreviations were used in this manuscript:

AMR	Antimicrobial Resistance
AMS	Antimicrobial Stewardship
GRADE	Grading of Recommendations, Assessment, Development and Evaluation
HCP	Healthcare Professionals
IBM	International Business Machine
IT	Information Technology

KAP	Knowledge, Attitudes, and Practices
LMICs	Low and Middle-Income Countries
NAP	National Action Plan
NY	New York
SPSS	Statistical Package for Social Sciences
STGs	Standard Treatment Guidelines
TDRC	Tropical Diseases Research Centre
WHO	World Health Organisation
USA	United States of America

References

1. Murray, C.J.; Ikuta, K.S.; Sharara, F.; Swetschinski, L.; Robles Aguilar, G.; Gray, A.; Han, C.; Bisignano, C.; Rao, P.; Wool, E.; et al. Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *Lancet* **2022**, *399*, 629–655. [CrossRef]
2. Naghavi, M.; Vollset, S.E.; Ikuta, K.S.; Swetschinski, L.R.; Gray, A.P.; Wool, E.E.; Robles Aguilar, G.; Mestrovic, T.; Smith, G.; Han, C.; et al. Global burden of bacterial antimicrobial resistance 1990–2021: A systematic analysis with forecasts to 2050. *Lancet* **2024**, *404*, 1199–1226. [CrossRef] [PubMed]
3. Salam, M.A.; Al-Amin, M.Y.; Salam, M.T.; Pawar, J.S.; Akhter, N.; Rabaan, A.A.; Alqumber, M.A.A. Antimicrobial Resistance: A Growing Serious Threat for Global Public Health. *Healthcare* **2023**, *11*, 1946. [CrossRef] [PubMed]
4. Paneri, M.; Sevta, P.; Paneri, M.; Sevta, P. Overview of Antimicrobial Resistance: An Emerging Silent Pandemic. *Glob. J. Med. Pharm. Biomed. Updat.* **2023**, *18*, 11. [CrossRef]
5. Prestinaci, F.; Pezzotti, P.; Pantosti, A. Antimicrobial resistance: A global multifaceted phenomenon. *Pathog. Glob. Health* **2015**, *109*, 309–318. [CrossRef]
6. Dadgostar, P. Antimicrobial resistance: Implications and costs. *Infect. Drug Resist.* **2019**, *12*, 3903–3910. [CrossRef]
7. Pulingam, T.; Parumasivam, T.; Gazzali, A.M.; Sulaiman, A.M.; Chee, J.Y.; Lakshmanan, M.; Chin, C.F.; Sudesh, K. Antimicrobial resistance: Prevalence, economic burden, mechanisms of resistance and strategies to overcome. *Eur. J. Pharm. Sci.* **2022**, *170*, 106103. [CrossRef]
8. Harbarth, S.; Balkhy, H.H.; Goossens, H.; Jarlier, V.; Kluytmans, J.; Laxminarayan, R.; Saam, M.; Van Belkum, A.; Pittet, D. Antimicrobial resistance: One world, one fight! *Antimicrob. Resist. Infect. Control* **2015**, *4*, 49. [CrossRef]
9. Tang, K.W.K.; Millar, B.C.; Moore, J.E. Antimicrobial Resistance (AMR). *Br. J. Biomed. Sci.* **2023**, *80*, 11387. [CrossRef]
10. Mudenda, S.; Mufwambi, W.; Mohamed, S. The Burden of Antimicrobial Resistance in Zambia, a Sub-Saharan African Country: A One Health Review of the Current Situation, Risk Factors, and Solutions. *Pharmacol. Pharm.* **2024**, *15*, 403–465. [CrossRef]
11. Bell, B.G.; Schellevis, F.; Stobberingh, E.; Goossens, H.; Pringle, M. A systematic review and meta-analysis of the effects of antibiotic consumption on antibiotic resistance. *BMC Infect. Dis.* **2014**, *14*, 13. [CrossRef]
12. Ho, C.S.; Wong, C.T.H.; Aung, T.T.; Lakshminarayanan, R.; Mehta, J.S.; Rauz, S.; McNally, A.; Kintses, B.; Peacock, S.J.; de la Fuente-Nunez, C.; et al. Antimicrobial resistance: A concise update. *Lancet Microbe* **2025**, *6*, 100947. [CrossRef] [PubMed]
13. Mudenda, S.; Hakayuwa, C.M.; Lubanga, A.F.; Kasanga, M.; Daka, V.; Salachi, K.I.; Mwaba, M.; Chileshe, C.; Champo, M.; Kamayani, M.; et al. Global Antimicrobial Stewardship, Surveillance, and Infection Prevention and Control Programs: Leveraging One Health, Nanotechnology, and Artificial Intelligence to Combat Antimicrobial Resistance in a Climate-Impacted World. *Pharmacol. Pharm.* **2025**, *16*, 197–291. [CrossRef]
14. Gautam, A. Antimicrobial Resistance: The Next Probable Pandemic. *J. Nepal Med. Assoc.* **2022**, *60*, 225–228. [CrossRef] [PubMed]
15. Gahimbare, L.; Muvunyi, C.M.; Guessennd, N.A.K.; Rutanga, J.P.; Gashema, P.; Fuller, W.; Mwamelo, A.J.; Coulibaly, S.O.; Mosha, F.S.; Perovic, O.; et al. Antimicrobial Resistance in the WHO African Region: A Systematic Literature Review 2016–2020. *Antibiotics* **2024**, *13*, 659. [CrossRef]
16. Jindal, B.A.K.; Pandya, M.K.; Khan, M.I.D. Antimicrobial resistance: A public health challenge. *Med. J. Armed Forces India* **2015**, *71*, 178–181. [CrossRef]
17. Sartorius, B.; Gray, A.P.; Davis Weaver, N.; Robles Aguilar, G.; Swetschinski, L.R.; Ikuta, K.S.; Mestrovic, T.; Chung, E.; Wool, E.E.; Han, C.; et al. The burden of bacterial antimicrobial resistance in the WHO African region in 2019: A cross-country systematic analysis. *Lancet Glob. Health* **2024**, *12*, e201–e216. [CrossRef]
18. Nowbuth, A.A.; Asombang, A.W.; Tazinkeng, N.N.; Makinde, O.Y.; Sheets, L.R. Antimicrobial resistance from a One Health perspective in Zambia: A systematic review. *Antimicrob. Resist. Infect. Control* **2023**, *12*, 15. [CrossRef]
19. Nowbuth, A.; Asombang, A.; Tazikeng, N.; Makinde, O.; Sheets, L. Antimicrobial Resistance in Zambia: A Systematic Review. *Int. J. Infect. Dis.* **2022**, *116*, S17–S18. [CrossRef]

20. World Health Organization. Global Action Plan on Antimicrobial Resistance. Available online: https://apps.who.int/iris/handle/10665/193736 (accessed on 6 January 2023).

21. Willemsen, A.; Reid, S.; Assefa, Y. A review of national action plans on antimicrobial resistance: Strengths and weaknesses. *Antimicrob. Resist. Infect. Control* **2022**, *11*, 90. [CrossRef] [PubMed]

22. Matee, M.; Mshana, S.E.; Mtebe, M.; Komba, E.V.; Moremi, N.; Lutamwa, J.; Kapona, O.; Sekamatte, M.; Mboera, L.E.G. Mapping and gap analysis on antimicrobial resistance surveillance systems in Kenya, Tanzania, Uganda and Zambia. *Bull. Natl. Res. Cent.* **2023**, *47*, 12. [CrossRef]

23. Fuller, W.L.; Hamzat, O.T.; Aboderin, A.O.; Gahimbare, L.; Kapona, O.; Yahaya, A.A.; Kasambara, W.; Nikiema, J.B.; Ilboudo, D.W.; Mpundu, M.M. National action plan on antimicrobial resistance: An evaluation of implementation in the World Health Organization Africa region. *J. Public Health Afr.* **2022**, *13*, 2000. [CrossRef]

24. Charani, E.; Mendelson, M.; Pallett, S.J.C.; Ahmad, R.; Mpundu, M.; Mbamalu, O.; Bonaconsa, C.; Nampoothiri, V.; Singh, S.; Peiffer-Smadja, N.; et al. An analysis of existing national action plans for antimicrobial resistance—Gaps and opportunities in strategies optimising antibiotic use in human populations. *Lancet Glob. Health* **2023**, *11*, e466–e474. [CrossRef]

25. Fuller, W.L.; Aboderin, A.O.; Yahaya, A.; Adeyemo, A.T.; Gahimbare, L.; Kapona, O.; Hamzat, O.T.; Bassoum, O. Gaps in the implementation of national core elements for sustainable antimicrobial use in the WHO-African region. *Front. Antibiot.* **2022**, *1*, 1047565. [CrossRef]

26. Moirongo, R.M.; Aglanu, L.M.; Lamshöft, M.; Adero, B.O.; Yator, S.; Anyona, S.; May, J.; Lorenz, E.; Eibach, D. Laboratory-based surveillance of antimicrobial resistance in regions of Kenya: An assessment of capacities, practices, and barriers by means of multi-facility survey. *Front. Public Health* **2022**, *10*, 1003178. [CrossRef] [PubMed]

27. Zongo, E.; Dama, E.; Yenyetou, D.; Muhigwa, M.; Nikiema, A.; Dahourou, G.A.; Ouedraogo, A.S. On-site evaluation as external quality assessment of microbiology laboratories involved in sentinel laboratory-based antimicrobial resistance surveillance network in Burkina Faso. *Antimicrob. Resist. Infect. Control* **2024**, *13*, 3. [CrossRef] [PubMed]

28. Dyar, O.J.; Huttner, B.; Schouten, J.; Pulcini, C. What is antimicrobial stewardship? *Clin. Microbiol. Infect.* **2017**, *23*, 793–798. [CrossRef]

29. McKenzie, D.; Rawlins, M.; Del Mar, C. Antimicrobial stewardship: What's it all about? *Aust. Prescr.* **2013**, *36*, 116–120. [CrossRef]

30. Mendelson, M.; Morris, A.M.; Thursky, K.; Pulcini, C. How to start an antimicrobial stewardship programme in a hospital. *Clin. Microbiol. Infect.* **2020**, *26*, 447–453. [CrossRef] [PubMed]

31. Nathwani, D.; Varghese, D.; Stephens, J.; Ansari, W.; Martin, S.; Charbonneau, C. Value of hospital antimicrobial stewardship programs [ASPs]: A systematic review. *Antimicrob. Resist. Infect. Control* **2019**, *8*, 35. [CrossRef] [PubMed]

32. D'Arcy, N.; Ashiru-Oredope, D.; Olaoye, O.; Afriyie, D.; Akello, Z.; Ankrah, D.; Asima, D.; Banda, D.C.; Barrett, S.; Brandish, C.; et al. Antibiotic prescribing patterns in Ghana, Uganda, Zambia and Tanzania hospitals: Results from the global point prevalence survey (G-PPS) on antimicrobial use and stewardship interventions implemented. *Antibiotics* **2021**, *10*, 1122. [CrossRef]

33. Ashiru-Oredope, D.; Nabiryo, M.; Zengeni, L.; Kamere, N.; Makotose, A.; Olaoye, O.; Townsend, W.; Waddingham, B.; Matuluko, A.; Nambatya, W.; et al. Tackling antimicrobial resistance: Developing and implementing antimicrobial stewardship interventions in four African commonwealth countries through a health partnership model. *J. Public Health Afr.* **2023**, *14*, 2335. [CrossRef]

34. Ashiru-Oredope, D.; Garraghan, F.; Olaoye, O.; Krockow, E.M.; Matuluko, A.; Nambatya, W.; Babigumira, P.A.; Tuck, C.; Amofah, G.; Ankrah, D.; et al. Development and Implementation of an Antimicrobial Stewardship Checklist in Sub-Saharan Africa: A Co-Creation Consensus Approach. *Healthcare* **2022**, *10*, 1706. [CrossRef]

35. Lakoh, S.; Bawoh, M.; Lewis, H.; Jalloh, I.; Thomas, C.; Barlatt, S.; Jalloh, A.; Deen, G.F.; Russell, J.B.W.; Kabba, M.S.; et al. Establishing an Antimicrobial Stewardship Program in Sierra Leone: A Report of the Experience of a Low-Income Country in West Africa. *Antibiotics* **2023**, *12*, 424. [CrossRef]

36. Calvo-Villamañán, A.; San Millán, Á.; Carrilero, L. Tackling AMR from a multidisciplinary perspective: A primer from education and psychology. *Int. Microbiol.* **2023**, *26*, 1–9. [CrossRef]

37. Kotwani, A.; Gandra, S. Strengthening antimicrobial stewardship activities in secondary and primary public healthcare facilities in India: Insights from a qualitative study with stakeholders. *Indian J. Med. Microbiol.* **2023**, *41*, 59–63. [CrossRef]

38. Mudenda, S.; Chabalenge, B.; Daka, V.; Mfune, R.L.; Salachi, K.I.; Mohamed, S.; Mufwambi, W.; Kasanga, M.; Matafwali, S.K. Global Strategies to Combat Antimicrobial Resistance: A One Health Perspective. *Pharmacol. Pharm.* **2023**, *14*, 271–328. [CrossRef]

39. Chukwu, E.E.; Abuh, D.; Idigbe, I.E.; Osuolale, K.A.; Chuka-Ebene, V.; Awoderu, O.; Audu, R.A.; Ogunsola, F.T. Implementation of antimicrobial stewardship programs: A study of prescribers' perspective of facilitators and barriers. *PLoS ONE* **2024**, *19*, e0297472. [CrossRef] [PubMed]

40. Mudenda, S.; Daka, V.; Matafwali, S.K. World Health Organization AWaRe framework for antibiotic stewardship: Where are we now and where do we need to go? An expert viewpoint. *Antimicrob. Steward. Healthc. Epidemiol.* **2023**, *3*, e84. [CrossRef] [PubMed]

41. Zanichelli, V.; Sharland, M.; Cappello, B.; Moja, L.; Getahun, H.; Pessoa-Silva, C.; Sati, H.; van Weezenbeek, C.; Balkhy, H.; Simão, M.; et al. The WHO AWaRe (Access, Watch, Reserve) antibiotic book and prevention of antimicrobial resistance. *Bull. World Health Organ.* **2023**, *101*, 290–296. [CrossRef]

42. Hsia, Y.; Lee, B.R.; Versporten, A.; Yang, Y.; Bielicki, J.; Jackson, C.; Newland, J.; Goossens, H.; Magrini, N.; Sharland, M. Use of the WHO Access, Watch, and Reserve classification to define patterns of hospital antibiotic use (AWaRe): An analysis of paediatric survey data from 56 countries. *Lancet Glob. Health* **2019**, *7*, e861–e871. [CrossRef]

43. United Nations Environment Programme. World Leaders Commit to Decisive Action on Antimicrobial Resistance. 2024. Available online: https://www.unep.org/news-and-stories/press-release/world-leaders-commit-decisive-action-antimicrobial-resistance (accessed on 11 December 2024).

44. Clinton Health Access Initiatve. Over 3 Million Children Died from AMR-Related Infections in 2022. 2025. Available online: https://www.clintonhealthaccess.org/news/over-3-million-children-died-from-amr-related-infections-in-2022-major-study-shows/ (accessed on 22 July 2025).

45. Sharland, M.; Zanichelli, V.; Ombajo, L.A.; Bazira, J.; Cappello, B.; Chitatanga, R.; Chuki, P.; Gandra, S.; Getahun, H.; Harbarth, S.; et al. The WHO essential medicines list AWaRe book: From a list to a quality improvement system. *Clin. Microbiol. Infect.* **2022**, *28*, 1533–1535. [CrossRef] [PubMed]

46. Funiciello, E.; Lorenzetti, G.; Cook, A.; Goelen, J.; Moore, C.E.; Campbell, S.M.; Godman, B.; Tong, D.; Huttner, B.; Chuki, P.; et al. Identifying AWaRe indicators for appropriate antibiotic use: A narrative review. *J. Antimicrob. Chemother.* **2024**, *79*, 3063–3077. [CrossRef]

47. Saleem, Z.; Sheikh, S.; Godman, B.; Haseeb, A.; Afzal, S.; Qamar, M.U.; Imam, M.T.; Abuhussain, S.S.A.; Sharland, M. Increasing the use of the WHO AWaRe system in antibiotic surveillance and stewardship programmes in low-and middle-income countries. *JAC-Antimicrob. Resist.* **2025**, *7*, dlaf031. [CrossRef] [PubMed]

48. Versporten, A.; Zarb, P.; Caniaux, I.; Gros, M.F.; Drapier, N.; Miller, M.; Jarlier, V.; Nathwani, D.; Goossens, H.; Koraqi, A.; et al. Antimicrobial consumption and resistance in adult hospital inpatients in 53 countries: Results of an internet-based global point prevalence survey. *Lancet Glob. Health* **2018**, *6*, e619–e629. [CrossRef]

49. Boltena, M.T.; Woldie, M.; Siraneh, Y.; Steck, V.; El-Khatib, Z.; Morankar, S. Adherence to evidence-based implementation of antimicrobial treatment guidelines among prescribers in sub-Saharan Africa: A systematic review and meta-analysis. *J. Pharm. Policy Pract.* **2023**, *16*, 137. [CrossRef]

50. Mekonnen Eticha, E.; Gemechu, W.D. Adherence to guidelines for assessment and empiric antibiotics recommendations for community-acquired pneumonia at Ambo University Referral Hospital: Prospective observational study. *Patient Prefer. Adherence* **2021**, *15*, 467–473. [CrossRef]

51. Mudenda, S.; Lubanga, A.F.; Jamshed, S.; Biemba, B.; Sakala, R.; Chiyabi, M.; Kavubya, L.; Milambo, L.T.; Bumbangi, F.N.; Chizimu, J.Y.; et al. Point Prevalence Survey of Antibiotic Use in Level 1 hospitals in Zambia: Future Prospects for Antimicrobial Stewardship Programs. *Infect. Drug Resist.* **2025**, *18*, 887–902. [CrossRef]

52. Mudenda, S.; Kapolowe, K.; Chirwa, U.; Chanda, M.; Chanda, R.; Kalaba, R.; Fwoloshi, S.; Phiri, C.; Mwamba, M.; Chirwa, R.K.; et al. Antimicrobial Stewardship Impact on Antibiotic Use in Three Tertiary Hospitals in Zambia: A Comparative Point Prevalence Survey. *Antibiotics* **2025**, *14*, 284. [CrossRef] [PubMed]

53. Chizimu, J.Y.; Mudenda, S.; Yamba, K.; Lukwesa, C.; Chanda, R.; Nakazwe, R.; Shawa, M.; Chambaro, H.; Kamboyi, H.K.; Kalungia, A.C.; et al. Antibiotic use and adherence to the WHO AWaRe guidelines across 16 hospitals in Zambia: A point prevalence survey. *JAC-Antimicrob. Resist.* **2024**, *6*, dlae170. [CrossRef]

54. Mudenda, S.; Chilimboyi, R.; Matafwali, S.K.; Daka, V.; Lindizyani Mfune, R.; Arielle, L.; Kemgne, M.; Bumbangi, F.N.; Hangoma, J.; Chabalenge, B.; et al. Hospital prescribing patterns of antibiotics in Zambia using the WHO prescribing indicators post-COVID-19 pandemic: Findings and implications. *JAC-Antimicrob. Resist.* **2024**, *6*, dlae023. [CrossRef]

55. Cox, J.A.; Vlieghe, E.; Mendelson, M.; Wertheim, H.; Ndegwa, L.; Villegas, M.V.; Gould, I.; Levy Hara, G. Antibiotic stewardship in low- and middle-income countries: The same but different? *Clin. Microbiol. Infect.* **2017**, *23*, 812–818. [CrossRef]

56. Fadare, J.O.; Ogunleye, O.; Iliyasu, G.; Adeoti, A.; Schellack, N.; Engler, D.; Massele, A.; Godman, B. Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: Findings and implications. *J. Glob. Antimicrob. Resist.* **2019**, *17*, 132–136. [CrossRef] [PubMed]

57. Chitatanga, R.; Yiwombe, C.; Divala, O.; Msokera, M.P.; Banda, E.; Chadwala, H.; Gilmon, M.W.; Kaminyoghe, W.; Milala, H.; Kawerama, A.; et al. A baseline assessment of antimicrobial stewardship core element implementation in selected public hospitals in Malawi: Findings from the 2023 National Program Audit. *Front. Public Health* **2025**, *13*, 1588778. [CrossRef]

58. Otieno, P.A.; Campbell, S.; Maley, S.; Obinju Arunga, T.; Otieno Okumu, M. A Systematic Review of Pharmacist-Led Antimicrobial Stewardship Programs in Sub-Saharan Africa. *Int. J. Clin. Pract.* **2022**, *2022*, 3639943. [CrossRef]

59. Akpan, M.R.; Isemin, N.U.; Udoh, A.E.; Ashiru-Oredope, D. Implementation of antimicrobial stewardship programmes in African countries: A systematic literature review. *J. Glob. Antimicrob. Resist.* **2020**, *22*, 317–324. [CrossRef]

60. Zambia National Public Health Institute. *Multi-Sectoral National Action Plan on Antimicrobial Resistance 2017–2027*; Zambia National Public Health Institute: Lusaka, Zambia, 2017. Available online: https://www.afro.who.int/publications/multi-sectoral-national-action-plan-antimicrobial-resistance-2017-2027 (accessed on 22 July 2025).

61. Popoola, O.O. Implementing Antimicrobial Stewardship in Various Healthcare Settings. In *Antimicrobial Stewardship*; IntechOpen: Rijeka, Croatia, 2023; pp. 1–22, ISBN 978-1-83769-091-6.

62. Pauwels, I.; Versporten, A.; Ashiru-Oredope, D.; Costa, S.F.; Maldonado, H.; Porto, A.P.M.; Mehtar, S.; Goossens, H.; Anthierens, S.; Vlieghe, E. Implementation of hospital antimicrobial stewardship programmes in low- and middle-income countries: A qualitative study from a multi-professional perspective in the Global-PPS network. *Antimicrob. Resist. Infect. Control* **2025**, *14*, 26. [CrossRef]

63. Abd El Azeem Khalaf, Y.M.; Gad, Z.M.; Arafa, M.A.; Abdou, M.S. Awareness and perception of antimicrobial stewardship program among healthcare professionals in the hospitals of ministry of health and population, Egypt: Antimicrobial stewardship toolkit survey. *Antimicrob. Resist. Infect. Control* **2025**, *14*, 13. [CrossRef]

64. Mudenda, S.; Chabalenge, B.; Daka, V.; Jere, E.; Sefah, I.A.; Wesangula, E.; Yamba, K.; Nyamupachitu, J.; Mugenyi, N.; Mustafa, Z.U.; et al. Knowledge, awareness and practices of healthcare workers regarding antimicrobial use, resistance and stewardship in Zambia: A multi-facility cross-sectional study. *JAC-Antimicrob. Resist.* **2024**, *6*, dlae076. [CrossRef] [PubMed]

65. Jahromi, A.S.; Namavari, N.; Jokar, M.; Sharifi, N.; Soleimanpour, S.; Naserzadeh, N.; Rahmanian, V. Global knowledge, attitudes, and practices towards antimicrobial resistance among healthcare workers: A systematic review and meta-analysis. *Antimicrob. Resist. Infect. Control* **2025**, *14*, 47. [CrossRef] [PubMed]

66. Kalungia, A.C.; Mwambula, H.; Munkombwe, D.; Marshall, S.; Schellack, N.; May, C.; Jones, A.S.C.; Godman, B. Antimicrobial stewardship knowledge and perception among physicians and pharmacists at leading tertiary teaching hospitals in Zambia: Implications for future policy and practice. *J. Chemother.* **2019**, *31*, 378–387. [CrossRef] [PubMed]

67. Iskandar, K.; Molinier, L.; Hallit, S.; Sartelli, M.; Hardcastle, T.C.; Haque, M.; Lugova, H.; Dhingra, S.; Sharma, P.; Islam, S.; et al. Surveillance of antimicrobial resistance in low- and middle-income countries: A scattered picture. *Antimicrob. Resist. Infect. Control* **2021**, *10*, 63. [CrossRef] [PubMed]

68. Okolie, O.J.; Igwe, U.; Ismail, S.U.; Ighodalo, U.L.; Adukwu, E.C. Systematic review of surveillance systems for AMR in Africa. *J. Antimicrob. Chemother.* **2023**, *78*, 31–51. [CrossRef]

69. Yamba, K.; Chizimu, J.Y.; Mudenda, S.; Lukwesa, C.; Chanda, R.; Nakazwe, R.; Simunyola, B.; Shawa, M.; Kalungia, A.C.; Chanda, D.; et al. Assessment of Antimicrobial Resistance Laboratory-based Surveillance Capacity of Hospitals in Zambia: Findings and Implications for System Strengthening. *J. Hosp. Infect.* **2024**, *148*, 129–137. [CrossRef]

70. Diño, P.E.T.; Aquino, S.S.; Depante, D.D.M.; Peña, I.G. Determination of the Enablers and Challenges in the Implementation of Pharmacy-based Antimicrobial Stewardship (AMS) Program in a Level 3 Hospital in Manila. *Acta Med. Philipp.* **2024**, *58*, 50–66. [CrossRef]

71. Shamas, N.; Stokle, E.; Ashiru-Oredope, D.; Wesangula, E. Challenges of implementing antimicrobial stewardship tools in Low to Middle Income Countries (LMICs). *Infect. Prev. Pract.* **2023**, *5*, 100315. [CrossRef] [PubMed]

72. Harun, M.G.D.; Sumon, S.A.; Hasan, I.; Akther, F.M.; Islam, M.S.; Anwar, M.M.U. Barriers, facilitators, perceptions and impact of interventions in implementing antimicrobial stewardship programs in hospitals of low-middle and middle countries: A scoping review. *Antimicrob. Resist. Infect. Control* **2024**, *13*, 8. [CrossRef]

73. Baraka, M.A.; Alsultan, H.; Alsalman, T.; Alaithan, H.; Islam, M.A.; Alasseri, A.A. Health care providers' perceptions regarding antimicrobial stewardship programs (AMS) implementation—Facilitators and challenges: A cross-sectional study in the Eastern province of Saudi Arabia. *Ann. Clin. Microbiol. Antimicrob.* **2019**, *18*, 26. [CrossRef]

74. Scheepers, L.N.; Niesing, C.M.; Bester, P. Facilitators and barriers to implementing antimicrobial stewardship programs in public South African hospitals. *Antimicrob. Steward. Healthc. Epidemiol.* **2023**, *3*, e34. [CrossRef]

75. Lubanga, A.F.; Bwanali, A.N.; Kondowe, S.; Nzima, E.; Masi, A.; Njikho, Y.; Chitule, C.; Harawa, G.; Mudenda, S.; Mwale, G.; et al. Strengthening antimicrobial stewardship in public health facilities in Malawi through a participatory epidemiology approach. *JAC-Antimicrob. Resist.* **2025**, *7*, dlaf103. [CrossRef]

76. Wang, H.; Wang, H.; Yu, X.; Zhou, H.; Li, B.; Chen, G.; Ye, Z.; Wang, Y.; Cui, X.; Zheng, Y.; et al. Impact of antimicrobial stewardship managed by clinical pharmacists on antibiotic use and drug resistance in a Chinese hospital, 2010–2016: A retrospective observational study. *BMJ Open* **2019**, *9*, e026072. [CrossRef]

77. Majumder, M.A.A.; Rahman, S.; Cohall, D.; Bharatha, A.; Singh, K.; Haque, M.; Gittens-St Hilaire, M. Antimicrobial stewardship: Fighting antimicrobial resistance and protecting global public health. *Infect. Drug Resist.* **2020**, *13*, 4713–4738. [CrossRef] [PubMed]

78. Chizimu, J.Y.; Mudenda, S.; Yamba, K.; Lukwesa, C.; Chanda, R.; Nakazwe, R.; Simunyola, B.; Shawa, M.; Kalungia, A.C.; Chanda, D.; et al. Antimicrobial stewardship situation analysis in selected hospitals in Zambia: Findings and implications from a national survey. *Front. Public Health* **2024**, *12*, 1367703. [CrossRef]

79. Awulu, O.A.; Jenkins, A.; Balogun, B.A.; Chukwu, E.E.; Fasina, F.O.; Egwuenu, A.; Oduyebo, O.O.; Bamidele, T.A.; Cadmus, S.; Aworh, M.K.; et al. Prioritising intervention areas for antimicrobial resistance in Nigeria's human and animal health sectors using a mixed-methods approach. *One Health* **2025**, *20*, 101082. [CrossRef]

80. Khanal, S.; Acharya, U.; Trotter, A.B.; Tripathi, P.; Koirala, S.; Pahari, B.; Acharya, S.P. Challenges and opportunities in the implementation of an antimicrobial stewardship program in Nepal. *Antimicrob. Steward. Healthcare Epidemiol.* **2023**, *3*, e58. [CrossRef]

81. Mathew, P.; Ranjalkar, J.; Chandy, S.J. Challenges in Implementing Antimicrobial Stewardship Programmes at Secondary Level Hospitals in India: An Exploratory Study. *Front. Public Health* **2020**, *8*, 493904. [CrossRef]

82. Amir, A. Challenges and Solutions Towards Antimicrobial Stewardship Implementation. *Int. J. Infect. Dis.* **2023**, *130*, S39. [CrossRef]

83. Pham, G.N.; Dang, T.T.H.; Nguyen, T.A.; Zawahir, S.; Le, H.T.T.; Negin, J.; Schneider, C.H.; Fox, G.J. Health system barriers to the implementation of the national action plan to combat antimicrobial resistance in Vietnam: A scoping review. *Antimicrob. Resist. Infect. Control* **2024**, *13*, 12. [CrossRef]

84. Fuller, W.; Kapona, O.; Aboderin, A.O.; Adeyemo, A.T.; Olatunbosun, O.I.; Gahimbare, L.; Ahmed, Y.A. Education and Awareness on Antimicrobial Resistance in the WHO African Region: A Systematic Review. *Antibiotics* **2023**, *12*, 1613. [CrossRef] [PubMed]

85. Craig, J.; Hiban, K.; Frost, I.; Kapoor, G.; Alimi, Y.; Varma, J.K. Comparison of national antimicrobial treatment guidelines, African Union. *Bull. World Health Organ.* **2021**, *100*, 50. [CrossRef] [PubMed]

86. Moja, L.; Zanichelli, V.; Mertz, D.; Gandra, S.; Cappello, B.; Cooke, G.S.; Chuki, P.; Harbarth, S.; Pulcini, C.; Mendelson, M.; et al. WHO's essential medicines and AWaRe: Recommendations on first- and second-choice antibiotics for empiric treatment of clinical infections. *Clin. Microbiol. Infect.* **2024**, *30* (Suppl. 2), S1–S51. [CrossRef] [PubMed]

87. Mbugua, S.M.; Njoroge, G.; Kijogi, C.; Kamita, M.; Kimani, R.; Mwaura, P.; Aidi, B.W.; Gitaka, J. Exploring perspectives on antimicrobial stewardship: A qualitative study of health managers in Kenya. *Glob. Health Res. Policy* **2020**, *5*, 49. [CrossRef] [PubMed]

88. Salem, M.R.; Youssef, M.R.L.; Shalaby, S.F.; Mahmoud, A.T.; Ismail, M.; Ibrahim, S.K. Perspectives on Antibiotic Stewardship Programs among Health Care Providers at Two University Hospitals in Egypt. *Int. J. Environ. Res. Public Health* **2023**, *20*, 3777. [CrossRef]

89. Kimbowa, I.M.; Eriksen, J.; Nakafeero, M.; Obua, C.; Lundborg, C.S.; Kalyango, J.; Ocan, M. Antimicrobial stewardship: Attitudes and practices of healthcare providers in selected health facilities in Uganda. *PLoS ONE* **2022**, *17*, e0262993. [CrossRef]

90. Vicentini, C.; Libero, G.; Cugudda, E.; Gardois, P.; Zotti, C.M.; Bert, F. Barriers to the implementation of antimicrobial stewardship programmes in long-term care facilities: A scoping review. *J. Antimicrob. Chemother.* **2024**, *79*, 1748–1761. [CrossRef]

91. Raka, L.; Kurti, A. Addressing barriers in antimicrobial stewardship: A guide from research to implementation. *J. Glob. Antimicrob. Resist.* **2024**, *39*, 26. [CrossRef]

92. Gebretekle, G.B.; Mariam, D.H.; Abebe, W.; Amogne, W.; Tenna, A.; Fenta, T.G.; Libman, M.; Yansouni, C.P.; Semret, M. Opportunities and barriers to implementing antibiotic stewardship in low and middle-income countries: Lessons from a mixed-methods study in a tertiary care hospital in Ethiopia. *PLoS ONE* **2018**, *13*, e0208447. [CrossRef]

93. Kakkar, A.K.; Shafiq, N.; Singh, G.; Ray, P.; Gautam, V.; Agarwal, R.; Muralidharan, J.; Arora, P. Antimicrobial Stewardship Programs in Resource-Constrained Environments: Understanding and Addressing the Need of the Systems. *Front. Public Health* **2020**, *8*, 140. [CrossRef]

94. Kaniu, M.W.; Gitaka, W.R.; Jain, R.; Munyare, A.N.; Adam, R.D.; Monroe-Wise, A. Knowledge, attitudes, and practices regarding antimicrobial resistance and antimicrobial stewardship among healthcare workers in outpatient medical centers in Kenya: A qualitative study. *Antimicrob. Steward. Healthcare Epidemiol.* **2025**, *5*, e113. [CrossRef] [PubMed]

95. Chapman, A.; Buccheri, A.; Mohotti, D.; Wong Shee, A.; Huggins, C.E.; Alston, L.; Hutchinson, A.M.; Yoong, S.L.; Beks, H.; Mc Namara, K.; et al. Staff-reported barriers and facilitators to the implementation of healthcare interventions within regional and rural areas: A rapid review. *BMC Health Serv. Res.* **2025**, *25*, 331. [CrossRef]

96. Howard, S.J.; Catchpole, M.; Watson, J.; Davies, S.C. Antibiotic resistance: Global response needed. *Lancet Infect. Dis.* **2013**, *13*, 1001–1003. [CrossRef] [PubMed]

97. Saleh, D.; Farha, R.A.; Alefishat, E. Impact of educational intervention to promote Jordanian community pharmacists' knowledge and perception towards antimicrobial stewardship: Pre-post interventional study. *Infect. Drug Resist.* **2021**, *14*, 3019–3027. [CrossRef] [PubMed]

98. Bulabula, A.N.H.; Jenkins, A.; Mehtar, S.; Nathwani, D. Education and management of antimicrobials amongst nurses in Africa-a situation analysis: An Infection Control Africa Network (ICAN)/BSAC online survey. *J. Antimicrob. Chemother.* **2018**, *73*, 1408–1415. [CrossRef] [PubMed]

99. Rolfe, R.; Kwobah, C.; Muro, F.; Ruwanpathirana, A.; Lyamuya, F.; Bodinayake, C.; Nagahawatte, A.; Piyasiri, B.; Sheng, T.; Bollinger, J.; et al. Barriers to implementing antimicrobial stewardship programs in three low- and middle-income country tertiary care settings: Findings from a multi-site qualitative study. *Antimicrob. Resist. Infect. Control* **2021**, *10*, 60. [CrossRef]

100. Nassar, H.; Abu-Farha, R.; Barakat, M.; Alefishat, E. Antimicrobial Stewardship from Health Professionals' Perspective: Awareness, Barriers, and Level of Implementation of the Program. *Antibiotics* **2022**, *11*, 99. [CrossRef]