International Health 2026; **18**: 894–904
https://doi.org/10.1093/inthealth/ihag026 Advance Access publication 23 May 2026

ORIGINAL ARTICLE

Identifying components for antimicrobial stewardship in primary healthcare centres in Nigeria: findings from an open call

Yusuf Babatunde [a,b,*,†], Moriam Adesola Adegbite[a,b], Latifat Abdulkarim[c], Oladotun Okediji[a], Abiodun Egwuenu[d,e], Francesca Chiara[f], Naomi Chikezie[b], Estelle Mbadiwe[g] and Eneyi E. Kpokiri[h,i]

[a]Faculty of Pharmaceutical Sciences, University of Ilorin, 240003 Ilorin, Nigeria; [b]Alliance Against Antimicrobial Resistance, 200131 Ibadan, Nigeria; [c]Alliance for Sustainable Livestock, 800001 Kaduna, Nigeria; [d]Nigeria Field Epidemiology and Laboratory Training Programme, 900108 Abuja, Nigeria; [e]Institute of Public Health, Charite - Universitätmedizin, Charitéplatz 1, 10117 Berlin, Germany; [f]The AMR Narrative, Cheshire WA14 2PX, UK; [g]Ducit Blue Solutions, 900110 Abuja, Nigeria; [h]Department of Clinical Research, Faculty of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, WC1E 7HT London, UK; [i]Social Engagement to Spur Health, 510095 Guangzhou, China

*Corresponding author: Tel: +234 703 540 9371; E-mail: yusufbabs916@gmail.com

[†]Present address: Faculty of Pharmaceutical Sciences, University of Ilorin, Ilorin, Nigeria.

Received 13 September 2025; revised 9 January 2026; accepted 12 February 2026

Background: Primary Health Centres (PHCs) in low- and middle-income countries (LMICs) struggle with the inappropriate use of antimicrobials, contributing to antimicrobial resistance (AMR). Antimicrobial Stewardship Programmes (ASPs) in these regions are often designed by experts from high-income countries, undermining their relevance to local settings. Crowdsourcing could be an effective strategy to engage local stakeholders and generate strategies that inform ASPs tailored to their specific contexts.

Methods: A six-week crowdsourcing open call was conducted from 15 April to 30 May 2024, following the WHO/TDR six-stage framework. Eligible submissions were evaluated based on a pre-specified judging rubric. Inductive thematic analysis was performed on high-scoring submissions, while descriptive analysis was carried out on demographic data.

Results: The call received 75 submissions from 19 countries, 45 of which were selected for thematic analysis. Six key themes emerged: Leadership and structure, Capacity building and communication, Digital tools and technology, Monitoring and evaluation, Collaboration and partnership, and Policies and guidelines.

Conclusions: Insights obtained through this open call can serve as foundational components of an ASP framework relevant to the unique contexts of PHCs in Nigeria. However, further validation is required to ensure the practical applicability of these proposed components.

Keywords: antimicrobial resistance, antimicrobial stewardship, crowdsourcing, low- and middle-income countries, Nigeria, primary healthcare.

Introduction

Antimicrobial resistance (AMR) is an urgent threat globally and is worse in low- and middle-income countries (LMICs), where the burden of infectious diseases is substantial. Although AMR is a global priority, antimicrobial stewardship programmes (ASPs) have been widely commended and endorsed for addressing growing AMR.[1] ASPs broadly refer to strategies and interventions that optimise antimicrobial use and ultimately reduce AMR. Most LMIC hospitals do not have ASPs, contributing to unnecessary antibiotic use and greater adverse outcomes attributable to AMR.[2] But more importantly, there is limited community engagement in the development of AMR programmes.[3,4] Most people in LMICs have limited opportunities for community engagement in addressing AMR.[3]

© The Author(s) 2026. Published by Oxford University Press on behalf of Royal Society of Tropical Medicine and Hygiene. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (https://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site-for further information please contact journals.permissions@oup.com

ASPs have been shown to improve antimicrobial prescribing practices and reduce resistance, but their implementation and sustainability are challenging, particularly in LMICs.[5–7] The national action plan (NAP) is an official document outlining a country's strategic plan and priorities to address growing AMR and is modelled on the global action plan on AMR, with its fourth objective being to optimise the use of antimicrobial medicines in humans and animals.[8] Member countries have included antimicrobial stewardship (AMS) or some form of optimisation of antimicrobial consumption in their NAPs. For instance, the fifth objective of Nigeria's National Action Plan (2024–2028) calls for improving access to quality antimicrobials and optimising their use across the One Health sector through stewardship programmes.[9]

Although the WHO has released a toolkit for implementing AMS in LMICs, specific guidance relevant to low-resource settings and workable in primary healthcare centres (PHCs) is required. For instance, a previous study exploring barriers to implementing international AMS guidelines in LMICs found that the local context and scarce resources in Nigerian hospitals present a giant obstacle to the implementation of the current WHO guidelines (2019).[8] The study concluded that data collected from local settings must directly inform the development of future international guidelines to increase feasibility and implementation rates.[8]

Primary healthcare constitutes an integral part of a country's healthcare system and is the level of care responsible for providing basic healthcare services to the general populace, particularly in rural areas. However, previous research has reported inappropriate prescribing and misuse of antibiotics across many PHCs in Nigeria.[7,8] There is a gap in the understanding of how ASPs can work optimally in PHCs, particularly in rural and remote contexts. The implementation of ASPs in settings such as PHCs is less well established because of shortages of healthcare professionals, limited access to therapeutic tools like medicines and vaccines, as well as the fact that most research on the effectiveness and implementation of its strategies has been conducted in hospital (secondary and tertiary) settings.[10]

In response to this need to understand how ASPs work in PHCs, we organised a crowdsourcing open call, soliciting practical ideas from individuals or groups in the AMR field. Crowdsourcing is defined as a group of people solving a problem and implementing selected solutions, typically in a bottom-up approach.[11] This method leverages local strengths to develop interventions in a community-engaged way. Its value has been well examined in the context of community participation and equity in intervention development. It has also been used in many disciplines to enhance stakeholder engagement and increase public involvement and accountability. Preliminary data from previous studies demonstrate that crowdsourcing activities such as open calls are feasible in LMICs and can be applied in Nigeria for AMR, where there is substantial antibiotic misuse.[12,13] Crowdsourcing approaches have been successfully employed in health research globally. A notable example is the Social Innovation in Health Initiative (SIHI)/Social Engagement to Spur Health (SESH) Youth Open call in the Philippines, where young people aged 15–30 y submitted innovative ideas to support the coronavirus disease 2019 (COVID-19) response.[14] In this open call, finalists were engaged in a mentored civic hackathon, underscoring the value in generating locally relevant solutions that reflect community priorities and contextual realities.

The purpose of the crowdsourcing open call was to identify and gather innovative ideas and practical tips related to ASPs in low-resource settings. These findings are intended to serve as a foundational taxonomy of strategies to inform the future development of a comprehensive ASP framework for PHCs in Nigeria.

Methods

Overview

The crowdsourcing open call was organized in accordance with the WHO/TDR (The Special Programme for Research and Training in Tropical Diseases) Practical Guide on Crowdsourcing in Health and Health Research.[15] The stages are outlined in Table 1. Crowdsourcing was utilised to potentially spur ideas and practical examples from a broad and representative pool of the public.

Organising a steering and organising committee

We coordinated a steering committee of nine representatives from Nigeria, Kenya, Rwanda, South Africa, the UK and the USA. The committee comprised AMR experts from academia, hospitals, community-based organisations, youth-led organisations and international non-governmental organisations. The committee met every other month on Zoom to provide high-level guidance on the specifics of the open call. They convened to set objectives, draft promotional strategies, develop evaluation criteria and recommend judges. On the other hand, the organising committee was responsible for managing the day-to-day operations of the open call. This included developing a dedicated website with all relevant information, encouraging submissions through online promotion and responding to participant inquiries via E-mail and an informational webinar on Zoom.

Engaging the community to contribute

The Alliance Against Antimicrobial Resistance (Triple A) launched and promoted the open call on 15 April until 30 May 2024 on its social media platforms (X, formerly Twitter, Instagram and LinkedIn) using an infographic (Figure 1) accompanied by descriptive text that directs prospective participants to the website for more information. On the website, three prompts were included to guide submissions: (i) 'Do you have practical ideas for implementing effective antimicrobial stewardship programs in low- and middle-income countries?'; (ii) What challenges did you encounter with your antimicrobial stewardship program, and how did you overcome them?'; and (iii) 'What activities were key ingredients for the success of your stewardship program?'. Additional assets such as E-mail blasts, flyers and a video were further used to promote the open call. Six partner organisations further promoted the open call across their network.

Receiving and evaluating contributions

Submissions to the open call were collected via a submission form hosted on the online survey platform, Jotform. Participants could submit their practical tips relating to ASPs in low-resource settings as written text (no more than 500 words) or a video/audio description (no more than 3 min long) under one of three

Table 1. Overview of the crowdsourcing open call stages, structure and function

Open call stage	Structure	Function
Organise a steering, organising and judging committee	Diverse group of stakeholders from academia, non-governmental organisations and youth groups	Steering committee: sets out rules for the open call and approves the call for submissions; organising committee: promotes the open call and convenes other groups; judging committee: evaluates submissions
Engage community to contribute	Social media promotion and informational webinars through videoconference	Encourage submissions and clarify the objectives of the open call
Receive and evaluate contributions	Judging committee evaluates the submissions based on a pre-set rubric; steering committee identifies finalists	Identify top and exceptional ideas from the pool of submissions
Recognise top finalists	Incentives for exceptional submissions	Acknowledge top and exceptional submissions
Share top finalists and plan for next steps	Website featuring summaries of finalists	Celebrate and promote top and exceptional submissions among the general public



Figure 1. Crowdsourcing open call promotional flyer. Dissemination channels for the crowdsourcing open call included social media platforms (X, formerly Twitter, Instagram and LinkedIn), partner organisations' mailing lists and professional networks.

categories: process description (description of a process or segment that is part of a stewardship programme), outcome evaluation (evaluation of the outcomes of a stewardship programme) or strategy for organising a stewardship programme (description and/or evaluation of strategies used to organise and sustain a stewardship programme). Participants could submit ideas as individuals or as a team of up to four members. For group submissions, only one member's demographics and other data were collected, and there were no residency restrictions for this open call. Once the eligibility screening was concluded, submissions were judged by a panel of 15 independent judges consisting of AMS experts, infectious disease specialists, researchers, AMR

programme implementers and health practitioners. All judges were given a standardised judging rubric (Supplementary Table 1) explaining the scoring system and conflict-of-interest procedures. Each judge received an average of 14 submissions, with each submission receiving at least three independent scores. In addition, judges also had the opportunity to clarify concepts with the open call organising group via a telephone call. Submissions were judged based on five criteria: (i) relevance to the open call (1–10 points); (ii) clear description of the proposed strategies (1–10 points); (iii) the potential for enhancing AMS (1–10 points); (iv) innovation in resource-constrained settings (1–10 points); and (v) the potential for implementation and sustainability (1–10 points). Inter-rater reliability was not formally calculated, but scores were averaged across judges. The final score was an average of these independent reviews. A cut-off score of $\geq$7.0/10 was established to identify 'top submissions' for recognition, ensuring that only high-quality, actionable ideas were analysed.

Recognising and disseminating exceptional submissions

Certificates of participation and commendation were awarded to eligible participants and exceptional participants, respectively. The top four participants received paid registration to take the course titled 'How to Set Up an Antimicrobial Stewardship Program' in partnership with the British Society of Antimicrobial Chemotherapy and International Centre for Antimicrobial Resistance Solutions.

Thematic data analysis

Data from the crowdsourcing open call were compiled, and the demographic data were analysed using measures of frequency distribution as descriptive statistics. We then conducted inductive thematic analysis following the six-phase approach described by Braun and Clarke.[16] All submissions scoring >5.0/10 were included in the analysis. This threshold was set because submissions scoring <5.0 typically lacked sufficient depth for meaningful coding. Two authors (YB and MA) independently coded the collected data using Microsoft Word to develop a preliminary codebook, resolve discrepancies and refine definitions. The codebook was applied to all submissions using Dedoose for data management. Codes were iteratively grouped into themes and subthemes through team discussions involving the authors (YB, MA, AE, FC, EEK). An inductive coding approach was used, where codes were derived directly from the data rather than pre-existing theories. Disagreements in coding were resolved through consensus meetings with a third reviewer.

Ethical considerations

We meticulously adhered to ethical norms throughout this research. An application for ethical approval was submitted to the National Health Research Ethics Committee (NHREC) of Nigeria, but we were granted exemption as the study was non-sensitive, blind and involves little to no risk to participants. Informed consent was obtained electronically through the submission form, where participants explicitly agreed to: (i) have their submissions modified and used for learning, research and implementation purposes; (ii) participate in subsequent Delphi surveys to refine framework outputs; and (iii) be contacted regarding the ASP framework development. Personal data were stored on password-protected servers accessible only to the research team, in compliance with data-protection regulations.

Results

Submission flow and screening

We received a total of 75 submissions from 19 different countries globally from 15 April to 30 May 2024 (Figure 2). Five submissions were excluded during eligibility screening and 70 eligible submissions proceeded to independent judging by the expert panel.

Participant characteristics

Geographic distribution

The majority of submissions originated from Africa, followed by Asia and Europe, with one submission having missing geographical data. By World Bank income classification, submissions came predominantly from lower-middle-income countries (56; 74.7%), followed by low-income countries (12; 16%), high-income countries (3; 4.0%) and upper-middle-income countries (3; 4.0%), with one submission with missing classification data.

Demographic characteristics

Detailed demographic characteristics of participants are presented in Table 2. Of the 75 submissions, 52 (69.3%) were individual entries, while 23 (30.7%) were groups of up to four members. Males comprised 43 (57.3%) submissions and females 31 (41.3%). The age distribution showed a predominance of young participants: 49 (65.3%) were aged 18–29 y, 15 (20.0%) 30–39 y, six (8.0%) 40–49 y and four (5.3%) were aged >50 y. In addition, educational attainment varied across all submissions, with 24 (32.0%) participants completing high school or diploma qualifications, 25 (33.3%) having bachelor's degrees, 18 (24.0%) with master's degrees, six (8.0%) with doctorate degrees and one (1.3%) reporting other qualifications. Similar to the geographical distribution, only one submission had missing gender, age and educational attainment data.

Judging outcomes and submission categories

After screening, 70 submissions were deemed eligible and moved forward for independent judging; 57 eligible submissions were categorised as strategies to organise stewardship programmes, nine as process evaluations or descriptions and two as outcome evaluations. After judging, the overall mean and median scores were 5.5/10 with a standard deviation (SD) of 1.2 and an interquartile range (IQR) of 1.8. We rated 10 submissions with a score $\geq$7/10 as top submissions. A summary description of the top-rated submissions can be found in Supplementary Table 2.

Forty-five entries (60%) scored >5/10 in the open call judging. Of these, only 33% specifically tailored their strategies to PHCs or low-resource settings, while others suggested programmes, interventions or strategies that are relevant in high-resource settings.

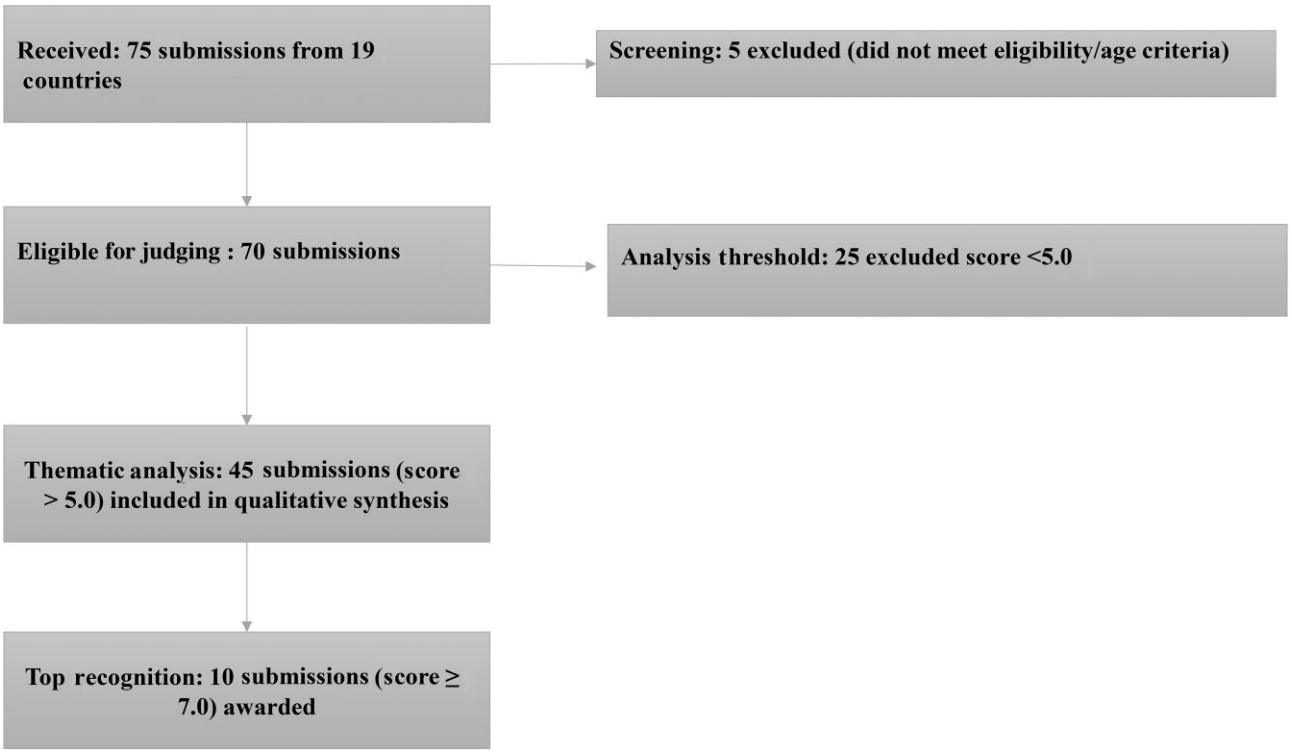


Figure 2. Flow diagram of the selection process.

Furthermore, six key categories (Figure 3) for implementing and sustaining ASPs in PHCs emerged from the analysis of the submissions: monitoring and evaluation (36 submissions), capacity building and communication (34), collaboration and partnerships (22), leadership and structure (19), digital tools and technology (18) and policies and guidelines (7).

Additionally, each strategy had descriptive subcategories. While some submissions covered only one strategy, many entries included two or more intersecting strategies and substrategies (Supplementary Table 3).

Thematic analysis

Theme 1: leadership and structure (19 submissions)

Leadership and structure allow for core elements that need to be put in place, including expertise, skills and facilities to implement ASPs in low-resource settings. Submissions in this category suggested various strategies, such as a stand-alone leadership structure or being embedded in another existing committee structure, with the primary objective of coordinating the programme according to its terms of reference. The submissions in this theme suggested infectious disease physicians, laboratory technicians, pharmacists, microbiologists and infection prevention and control (IPC) personnel as leadership committee members. Additionally, having them already employed at the facility is beneficial. Furthermore, some submissions recommended a leader or champion who would be responsible for leading the AMS team in implementing the ASP at the PHC (Supplementary Table 3, #50). The champion would also be responsible for coordinating the dissemination of regular reports, outcomes and trends in line with the facility's situation.

Illustrative quote: *A stewardship team with infectious disease specialists, pharmacists, microbiologists, and nurses should be formed in their health settings* (Supplementary Table 3, #26).

Theme 2: capacity building and communication (34 submissions)

Various submissions suggested using in-person and digital channels to educate primary healthcare providers on best practices in AMS, focusing on capacity building and developing information and communication materials on AMS at the facilities. Suggestions included periodically training clinicians to update them on modern trends in AMR with a focus on antibiotic susceptibility testing, specimen collection and the use of IT systems for analysing AMR patient data (Supplement Table 3, #22). These capacity-building sessions can include case studies, role-playing scenarios and interactive educational workshops. In addition, online platforms such as WhatsApp can be leveraged as a virtual space for continuing education so that primary healthcare providers can meet in one space to share knowledge, resources and case studies (Supplementary Table 3, #53).

Illustrative quote: *6 staff from each selected PHC will be trained on AMR and AMR stewardship using prepared topics by the committee. The lecture model will be physical to ensure the effectiveness of training and practical implementation in practice. Each PHC will consist of a team of health care providers in different departments of the hospital. 2 months will be for AMR and AMS*

Table 2. Characteristics of the study population (n=75)

Variable	Number (%)
Age (y)	
18–29	49 (65.3)
30–39	15 (20.0)
40–49	6 (8.0)
>50	4 (5.3)
Missing	1 (1.3)
Sex	
Male	43 (57.3)
Female	31 (41.3)
Missing	1 (1.3)
Highest education level completed	
High school/diploma	24 (32.0)
Bachelor's	25 (33.3)
Master's	18 (24.0)
Doctorate	6 (8.0)
Other	1 (1.3)
Missing	1 (1.3)
Country (by region)	
Africa	66 (88.0)
Asia	6 (8.0)
Europe	2 (2.7)
Missing	1 (1.3)
Country (by income)	
Low-income	12 (16.0)
Lower-middle income	56 (74.7)
Upper-middle income	3 (4.0)
High-income	3 (4.0)
Missing	1 (1.3)

training, and 1 month on pedagogy skills (Supplementary Table 3, #20).

Theme 3: digital tools and technology (18 submissions)

Eighteen submissions proposed using various digital tools and technology to optimise antimicrobial prescribing and dispensing in low-resource settings. Digitisation of audio tools to facilitate real-time data collection and monitoring was commonly mentioned. Proposed features of the tool include an AMS chart review, an AMS knowledge hub and microbiological data. Other submissions suggested integrating microbiological data and antibiotic sensitivity testing via software that provides real-time laboratory result updates and offers automated therapy adjustment recommendations based on culture and sensitivity findings when needed (Supplementary Table 3, #7).

Illustrative quote: *By implementing a digital tool for antimicrobial stewardship, we can facilitate real-time data collection rather than passive monitoring. An important aspect of this digital tool is the integration of microbiological data and sensitivity. The tool also provides real-time updates on lab results and offers automated recommendations for therapy adjustment based on culture and sensitivity findings when needed* (Supplementary Table 3, #7).

Theme 4: monitoring and evaluation (36 submissions)

Thirty-six submissions mentioned the need for effective antimicrobial therapy monitoring and auditing. Auditing was referred to in different ways from the submissions, including passive or real-time collection and analysis of antibiotic prescription data on hospitalised patients, which is then reported to prescribers. The open call suggests a more routine audit (weekly or bi-weekly) during ward rounds with the entire AMS multidisciplinary team for real-time feedback. Such an audit would be useful to assess ongoing infection management and antibiotic prescription at the healthcare facility.

Illustrative quote: *Without an audit, the process of antimicrobial prescribing practice behaviour cannot be evaluated and improved in line with global best practices. In most health facilities, with the support of hospital management, antimicrobial auditors will be constituted to undergo surveillance at least 2 to 3 times a week to ensure that the appropriate prescribing practices are being carried out by prescribing physicians. A very important component of this process is feedback to physicians, which should be educational and evidence-based (data-driven)…* (Supplementary Table 3, #19).

Theme 5: collaboration and partnerships (22 submissions)

Twenty-two submissions discussed collaboration and partnerships to make ASPs sustainable in low-resource settings. Suggestions include promoting local ownership of ASPs and integration into existing systems. This includes partnership and collaboration with national and international organisations for technical assistance, funding, sharing best practice and mobilising resources. The importance of building the young generation's capacity was also mentioned through a revamp of healthcare students' preservice curricula to ensure the long-term sustainability of educational activities. Expansion of ASPs within the One Health scope was also suggested (Supplementary Table 3, #65).

Illustrative quote: *Collaborate with government agencies, international organisations, non-governmental organisations (NGOs), academic institutions, and private sector partners to mobilise resources, share best practices, and scale up antimicrobial stewardship interventions. Secure funding and resources for stewardship activities and ensure long-term sustainability* (Supplementary Table 3, #36).

Theme 6: policies and guidelines (7 submissions)

Seven submissions suggested developing and using localised standard treatment guidelines (STGs) and policies to control antibiotic access in resource-limited settings. STGs should reflect surveillance and consumption data in a particular community. Such information helps limit antibiotic use, improve patient care, change behaviours and enhance cost savings. STGs should therefore be readily adaptable for local implementation. Various strategies were suggested, including developing evidence-based clinical guidelines and treatment pathways for common infectious diseases encountered in primary care. These guidelines should emphasise antibiotic selection, dosing, duration and de-escalation strategies (Supplementary Table 3, #72). Also, a limited formulary with preferred antimicrobials based on

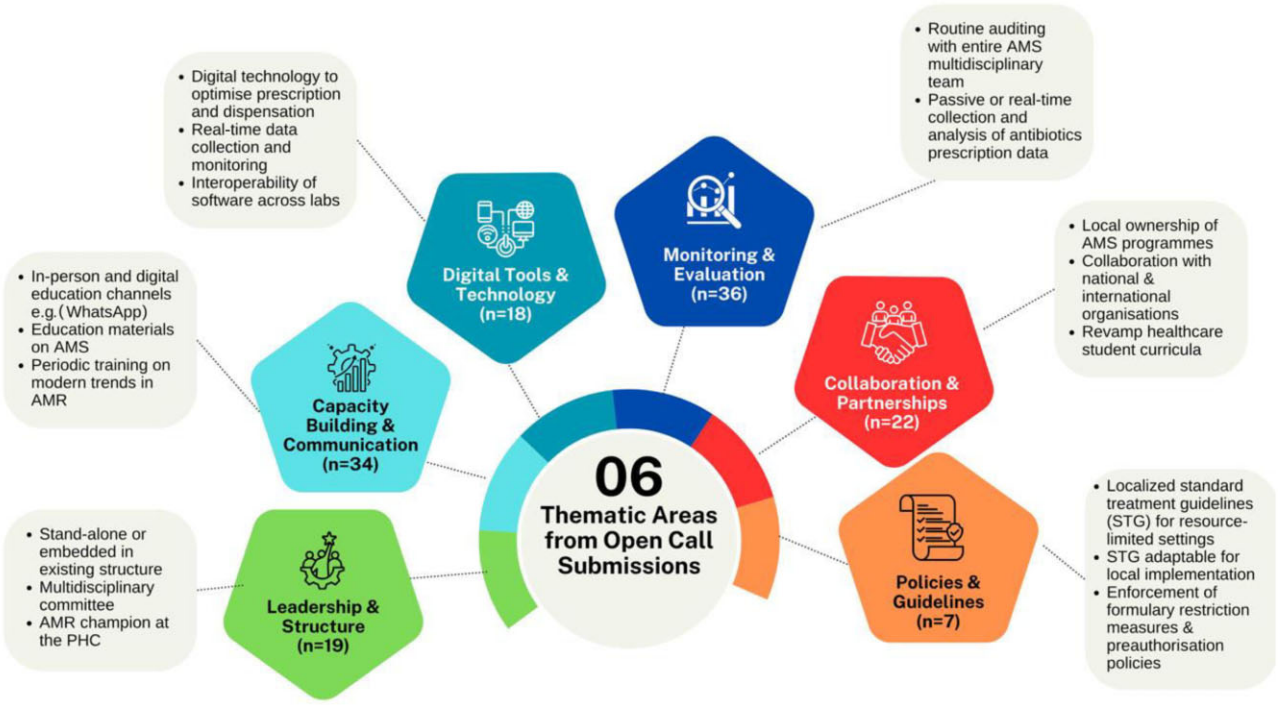


Figure 3. Emergent themes from the analysis of the open call submissions. Analysis of open call submissions revealed six key categories: leadership and structure; capacity building and communication; digital tools and technology; monitoring and evaluation; collaboration and partnerships; and policies and guidelines. AMR: antimicrobial resistance; AMS: antimicrobial stewardship; PHC: primary health centre.

local resistance patterns must be developed and implemented (Supplementary Table 3, #26). Formulary restriction measures and preauthorisation policies should be enforced to control access to restricted or high-cost antibiotics (Supplementary Table 3, #36).

Illustrative quote: *Develop evidence-based clinical guidelines and treatment pathways for common infectious diseases encountered in primary care. These guidelines should emphasise antibiotic selection, dosing, duration, and de-escalation strategies* (Supplementary Table 3, #72).

Discussion

This crowdsourcing open call engaged stakeholders across 19 countries to solicit ideas and suggestions to develop potential strategies for implementing ASPs in PHCs in low-resource settings. Through thematic analysis of 75 submissions, we identified six key thematic components informing the design and development of a comprehensive, innovative, sustainable and cost-effective AMS framework for PHCs in LMICs: leadership and structure, capacity building and communication, digital tools and technology, monitoring and evaluation, collaboration and partnerships; and policies and guidelines. This section elucidates the key findings for this paper-based framework on the theme identified in the thematic analysis.

The most cited strategy from the open call was monitoring and evaluation, which highlights the important role of continuous assessment and feedback processes when carrying out activities that aim to optimise antimicrobial use. This aligns with a study that emphasised routine audits and real-time feedback as a practical approach to ensuring adherence to AMS protocols in resource-limited LMICs.[2] Implementing routine monitoring and evaluation systems can facilitate the early detection of resistance trends, enabling timely interventions. In addition, the predominance of monitoring and evaluation also aligns closely with established AMS frameworks. Both the WHO 2019 Practical Toolkit for antimicrobial stewardship programmes in healthcare facilities and the CDC Core Elements of Hospital Antibiotic Stewardship Programs identify tracking and reporting as foundational components.[17,18] This convergence between crowdsourced stakeholder priorities and expert-developed guidelines validates the community's recognition that stewardship requires systematic measurement and feedback. However, our findings extend existing frameworks by emphasising approaches specifically adapted to resource constraints, such as simplified audit tools and peer-to-peer feedback mechanisms that do not require electronic medical records (EMRs).

Capacity building and communication were highlighted as the second most common theme received in the submissions, showing the need for continuous education and training of healthcare service providers. The combination of in-person and digital training methods demonstrates an innovative and cost-efficient approach to overcoming barriers such as distance and limited access to traditional training resources in low-resource settings, using interactive workshops and social media platforms like

WhatsApp. This finding aligns with a study that advocated for flexible and context-specific educational interventions to improve AMS competencies in LMICs.[1,2,19] Capacity building through diverse educational modalities ensures that healthcare providers are well-equipped to adhere to AMS protocols.

In addition, collaborations and partnerships were identified as crucial for the sustainability of ASPs. The need to build local ownership while integrating AMS into existing healthcare systems, especially in PHCs, can strengthen and facilitate resource sharing and technical support, thereby ensuring programme sustainability.

Partnerships with government bodies at local, national and regional levels and with national and international organisations can provide the required technical assistance and funding, addressing one of the primary challenges of LMICs: resource scarcity.[7] For instance, Nigeria's National Action Plan on AMR (2024–2028) similarly calls for strengthened partnerships between government, civil society and development partners.[9] In addition, the Fleming Fund's support for ASP implementation in several African countries has generated learning around adaptation to local contexts.[20] Taken together, these examples underscore the critical role of collaborative, well-resourced partnerships in advancing AMS in LMICs, reinforcing that sustained progress will depend on coordinated actions across government, civil societies and international stakeholders.

Moreover, the leadership and structure theme identified in the open call highlights the importance of establishing dedicated AMS committees or incorporating stewardship roles within existing structures, rather than creating new ones. Effective leadership is crucial for coordinating ASPs, sharing information and ensuring accountability. The suggestion to appoint AMS champions under this theme aligns with best practice that identifies key individuals who can drive programme implementation and promote responsible antimicrobial use.[4]

While the open call successfully generated a diverse range of ideas, it is pertinent to interpret these findings within the current context of PHCs in Nigeria. For instance, under the leadership and structure theme, several submissions suggested the inclusion of infectious disease physicians and microbiologists in stewardship teams. However, in rural areas in Nigeria, there is a prevalent shortage of specialised human resources in PHCs, and many facilities are being managed by nurses or community health extension workers rather than specialised physicians. Therefore, while the ideal framework includes the inclusion of specialists, a suitable framework in the Nigerian PHC context must rely on task shifting, where the existing staff (e.g. senior nurses and community health extension workers [CHEWs]) are trained to lead AMS activities, or specialists at public hospitals are assigned to oversee multiple PHCs. This approach has proven successful in Nigeria, as demonstrated in some studies.[21,22] As such, future frameworks must filter these suggestions through a feasibility lens to ensure applicability in a resource-constrained environment.

Furthermore, using digital tools and technology is identified as a key strategy in the open call and demonstrates a futuristic approach to AMS. Suggestions revolved around integrating real-time data collection and automated decision support systems. While implementing such technologies may pose challenges in low-resource settings, their potential to streamline AMS processes and provide timely feedback is significant. This is particularly relevant as telemedicine and digital health solutions continue to gain traction globally, offering scalable and cost-effective options for enhancing AMS.[23]

Also, the policies and guidelines theme emphasises the necessity of localised STGs that reflect regional AMR patterns. Developing and enforcing STGs can standardise prescribing practices, reduce unnecessary antibiotic use and improve patient outcomes.[6] The emphasis on formulary restrictions and preauthorisation policies further illustrates the multifaceted approach required to control antibiotic access and usage effectively.[6] These policies must be adaptable to local contexts and supported by continuous training and leadership commitment to ensure effective implementation.

Robust IPC measures and water, sanitation, and hygiene (WASH) initiatives were among the other strategies proposed. Integrating AMS with IPC and WASH can create a comprehensive framework that addresses the broader social determinants of AMR, promoting a holistic approach to infection management.[13]

The insights gathered from this crowdsourced open call provide actionable strategies to inform the development of AMS frameworks tailored to the unique challenges of PHCs in LMICs. Our study further contributes to the already existing literature on the usefulness of crowdsourcing as a powerful tool to pool innovative ideas from communities and stakeholders rather than top-down solutions.[24] It also allowed access to first-hand data for local stakeholders in developing the AMS framework, which can be implemented in low-resource settings due to its rich and contextualised data.

Critical analysis: feasibility in Nigerian PHC contexts

As discussed in the Results section, only 33% of the submissions tailored their proposals to PHCs in low-resource settings. This highlights the potential risk of generating an ASP framework that is theoretically good but not scalable in low-resource settings like Nigeria. The following analysis evaluates the feasibility of the proposed interventions against the current operations of Nigerian PHCs.

Immediately feasible strategies

Several proposed approaches were in line with the existing infrastructure of Nigerian PHCs and can be implemented with minimal resources. Significantly, leadership and accountability, as suggested in submissions 26 and 50, can be implemented through task shifting, a strategy formally endorsed by the National Task Shifting and Sharing policy from the federal Ministry of Health.[25] This can be through the appointment of an AMS champion, such as a high-ranking CHEW, community health worker (CHO) or senior nurse, which leverages existing staff without the need for hiring more staff.[26] As such, this aligns with successful models in Nigerian rural health care; CHEWs effectively manage administrative and clinical oversights in the absence of physicians.[27–29]

Similarly, peer education and mentorship, as highlighted in submissions 1, 20 and 22, can be used in the 'train the trainer' approach.[30] This can be through case-based learning sessions led by experienced clinicians, strengthening prescribing practices without expensive infrastructure.[31] This is complemented by the simple audit and feedback mechanisms in submissions 1 and 2,

where transitioning from complex digital audits to weekly-based prescription reviews allows PHC staff to identify irrational antibiotic use.[32] Furthermore, enforcing localised treatment guidelines as stated in submission 26 is highly feasible given the existing National Standing Orders (NSO) and STGs.[33] As such, CHEWs are trained to follow the NSO for effective management, reinforcing adherence to these existing legal documents, which provide a ready-made framework for stewardship without requiring the creation of new protocols.

Strategies requiring adaptation

Certain suggestions hold promise but require significant modification to fit the PHC context.

First, the proposal for multidisciplinary stewardship teams, as seen in submissions 26 and 33, which typically include infectious disease physicians and clinical pharmacists, is unrealistic for rural PHCs, where there are limited human resources. Therefore, a feasible adaptation is the 'Hub-and-Spoke' model,[34] which has been feasible in secondary-care hospitals in India, improving antibiotic escalation rates in the country.[35] In this model, a secondary or tertiary hospital serves as the 'hub', providing virtual expertise and mentorship to a network of PHC 'spokes', creating a shared virtual stewardship team rather than requiring specialists onsite at every clinic.[34,35]

Second, regarding digital surveillance tools, as highlighted in submissions 7 and 53, the barriers of erratic power supply and poor internet connectivity in rural Nigeria cannot be overstated. Therefore, standard EMRs are unlikely to succeed. However, offline-capable mobile solutions offer a feasible alternative. For instance, the Surveillance Outbreak Response Management and Analysis System (SORMAS), widely used in Nigeria for Lassa fever and COVID-19 surveillance, demonstrates that mobile apps that store data offline and sync when connectivity is available are viable.[36,37] Adapting such existing familiar platforms for antibiotic tracking is more practical than introducing complex new software.

Finally, laboratory-guided therapy, as highlighted in submission 7, faces the hurdle of non-existent microbiology capacity in most PHCs. As such, the initiative must shift from culture-based stewardship to diagnostic stewardship using rapid diagnostic tests (RDTs), such as maximising the use of malaria RDTs to rule out parasitic infection before antibiotic use, as well as reliance on regional antibiograms from reference laboratories to guide empirical therapy.[38]

Aspirational strategies

Some proposals serve as long-term goals rather than as immediate interventions due to structural deficits.

First, the formulary restrictions and preauthorisation systems suggested in submission 36 presume a stable supply chain where 'approved' alternatives are always available. In reality, Nigerian PHCs often face stock-outs and are forced to procure medicines from open drug markets or patent medicine vendors, making strict formulary adherence impossible without first stabilising the national pharmaceutical supply chain.[39–41] Similarly, the advanced stewardship interventions stated by submission 6, such as intravenous-to-oral switching or dose optimisation, require a level of clinical pharmacology expertise and inpatient monitoring capacity that effectively does not exist at the primary-care level.[42] Lastly, building comprehensive resistance surveillance, as highlighted in submissions 7 and 62, requires a functional tiered laboratory network. While critical for national security, this demands substantial, long-term government investment in infrastructure and is beyond the scope of a facility-level ASP framework.[43]

Study limitations

A crowdsourcing open call is a participatory approach that solicits ideas and solutions from a broad, largely unrestricted or undefined public audience and returns the outputs, also known as crowdsourcing results, back to the general public. As such, this study has several important limitations that must be acknowledged.

First, the crowdsourcing approach in this study, while inclusive, introduced participation bias. Significantly, respondents required digital literacy and internet access, potentially excluding rural healthcare workers, CHOs and populations with limited connectivity, precisely those most affected by PHC-level AMS challenges. Additionally, the predominantly young age profile (65.3% of submitters were aged 18–29 y) may not fully represent experienced healthcare managers and policymakers. Second, we did not assess inter-rater reliability among judges, limiting our ability to quantify scoring consistency. In addition, geographic representation in the study was heavily skewed towards Africa, particularly Nigeria, limiting generalisability to other LMIC regions (Asia, Latin America). Moreover, with only 33% of submissions specifically tailored to PHCs or low-resource settings, many proposed approaches are more suitable for well-resourced hospitals.

Most importantly, this study identifies potential framework components but does not constitute a validated, implementable framework. Therefore, we acknowledge that the data from this open call are not robust enough to inform the development of the AMS framework independently. Moreover, the six themes identified represent a conceptual organisation requiring further work, such as conducting a Delphi study and a scoping review to identify evidence for each strategy; feasibility assessment in actual PHC settings; and pilot implementation with iterative refinement in low-resource settings.

Conclusion

The insights gathered from this crowdsourced open call provide actionable strategies that can partially inform the development of AMS frameworks tailored to the unique challenges of PHCs in LMICs. Future research should focus on validating the proposed AMS strategies through consensus approaches and pilot implementations in diverse PHC settings across various LMICs. Additionally, expanding the crowdsourcing approach to include a more diverse range of participants, particularly from underrepresented regions, can enrich the emerging foundational themes with a wider array of perspectives and solutions.

Supplementary data

Supplementary data are available at *International Health* online.

Author contributions: Yusuf Babatunde (Conceptualization [lead], Data curation [lead], Funding acquisition [lead], Investigation [supporting], Methodology [lead], Project administration [lead], Resources [lead], Software [lead], Visualization [supporting], Writing—original draft [lead], Writing—review & editing [lead]), Moriam Adegbite (Data curation [supporting], Formal Analysis [lead], Investigation [supporting], Methodology [supporting], Project administration [supporting], Writing—original draft [supporting]), Latifat Abdulkarim (Data curation [supporting], Writing—original draft [supporting]), Oladotun Okediji (Data curation [supporting], Investigation [supporting], Writing—original draft [supporting], Writing—review & editing [supporting]), Abiodun Egwuenu (Methodology [supporting], Supervision [supporting], Writing—review & editing [supporting]), Francesca Chiara (Methodology [supporting], Supervision [supporting], Writing—review & editing [supporting]), Naomi Chikezie (Project administration [supporting], Supervision [supporting]), Estelle Mbadiwe (Project administration [supporting], Supervision [supporting]), and Eneyi E. Kpokiri (Conceptualization [supporting], Funding acquisition [supporting], Methodology [supporting], Project administration [supporting], Supervision [supporting], Writing—review & editing [supporting])

Funding: This project was funded by National Institute for Health and Care Research (NIHR) as part of the Royal Society of Tropical Medicine and Hygiene (RSTMH) Early Career Research Grant 2023 [Grant number: NIHR23210].

Competing interests: The authors declare that there are no conflicts of interest.

Ethical approval: We meticulously adhered to ethical norms throughout this research. Application for ethical approval was submitted to the National Health Research Ethics Committee, but we were exempt as the study was non-sensitive, does not identify individuals and involves minimal risk to participants.

Data availability: The results drawn from this study are sufficiently supported by the data in the article and its supplementary data, as acknowledged by the authors.

References

1 Pallares C, Hernández-Gómez C, Appel TM, et al. Impact of antimicrobial stewardship programs on antibiotic consumption and antimicrobial resistance in four Colombian healthcare institutions. BMC Infect Dis. 2022;22:420. https://doi.org/10.1186/s12879-022-07410-6

2 Cox JA, Vlieghe E, Mendelson M, et al. Antibiotic stewardship in low- and middle-income countries: the same but different? Clin Microbiol Infect. 2017;23:812–8.

3 Mitchell J, Cooke P, Ahorlu C, et al. Community engagement: the key to tackling antimicrobial resistance (AMR) across a One Health context? Glob Public Health. 2021;17:1–18.

4 King R, Hicks J, Rassi C, et al. A process for developing a sustainable and scalable approach to community engagement: community dialogue approach for addressing the drivers of antibiotic resistance in Bangladesh. BMC Public Health. 2020;20:950. https://doi.org/10.1186/s12889-020-09033-5

5 Fadare JO, Ogunleye O, Iliyasu G, et al. Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: findings and implications. J Glob Antimicrob Resist. 2019;17:132–6.

6 Charani E, Cooke J, Holmes A. Antibiotic Stewardship programmes–what's missing? J Antimicrob Chemother. 2010;65:2275–7.

7 Aika IN, Enato E. Health care systems administrators perspectives on antimicrobial stewardship and infection prevention and control programs across three healthcare levels: a qualitative study. Antimicrob Resist Infect Control. 2022;11:157. https://doi.org/10.1186/s13756-022-01196-7

8 Munkholm L, Rubin O. The global governance of antimicrobial resistance: a cross-country study of alignment between the global action plan and national action plans. Global Health. 2020;16:109. https://doi.org/10.1186/s12992-020-00639-3

9 Federal Ministry of Health Nigeria. One Health Antimicrobial Resistance National Action Plan 2.0 2024–2028. 2024.

10 Chukwu EE, Oshun PO, Osuolale KA, et al. Antimicrobial stewardship programmes in healthcare facilities in Lagos State, Nigeria: a needs assessment. J Glob Antimicrob Resist. 2021;25:162–70.

11 Tucker JD, Day S, Tang W, et al. Crowdsourcing in medical research: concepts and applications. Peer J. 2019;7:e6762.

12 Kpokiri, E, Wu D, Srinivas ML, et al. Using a crowdsourcing open call, hackathon and a modified Delphi method to develop a consensus statement and sexual health survey instrument. medRxiv. 2020, https://doi.org/10.1101/2020.10.02.20205542

13 Kpokiri E, Budak JZ, Chang CC, et al. Innovative strategies to fight antimicrobial resistance: crowdsourcing to expand medical training. F1000Research. 2020;9:227–7.

14 Ulitin A, Mier-Alpaño JD, Labarda M, et al. Youth social innovation during the COVID-19 pandemic in the Philippines: a quantitative and qualitative descriptive analyses from a crowdsourcing open call and online hackathon. BMJ Innov. 2022;8(3):161–8.

15 World Health Organization, TDR (Special Programme for Research and Training in Tropical Diseases). Crowdsourcing in Health and Health Research: A Practical Guide. Geneva: WHO Press; 2018. Available at: https://tdr.who.int/publications/i/item/2018-07-11-crowdsourcing-in-health-and-health-research-a-practical-guide [accessed March 2, 2026].

16 Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101.

17 World Health Organization. Antimicrobial Stewardship Programmes in Health-Care Facilities in Low- and Middle-Income Countries: A Practical Toolkit. Geneva, Switzerland: WHO; 2019.

18 CDC. Core Elements of Hospital Antibiotic Stewardship Programs. Atlanta, GA: US Department of Health and Human Services, CDC; 2019. Available at: https://www.cdc.gov/antibiotic-use/core-elements/hospital.html.

19 Lakoh S, Li L, Sevalie S, et al. Antibiotic resistance in patients with clinical features of healthcare-associated infections in an urban tertiary hospital in Sierra Leone: a cross-sectional study. Antimicrob Resist Infect Control. 2020;9:38. https://doi.org/10.1186/s13756-020-0701-5

20 Fleming Fund. Commonwealth Partnerships for Antimicrobial Stewardship 2 (CwPAMS 2). UK aid-funded antimicrobial stewardship grant programme. UK: Fleming Fund/Department of Health and Social Care. Available at: https://www.flemingfund.org/grants/commonwealth-partnerships-for-antimicrobial-stewardship-2 [accessed March 2, 2026].

21 Charyeva Z, Oguntunde O, Orobaton N, et al. Task shifting provision of contraceptive implants to community health extension workers: results of operations research in northern Nigeria. Glob Health Sci Pract. 2015;3(3):382–94.

22 Akeju DO, Vidler M, Sotunsa JO, et al. Human resource constraints and the prospect of task-sharing among community health workers for

the detection of early signs of pre-eclampsia in Ogun State, Nigeria. Reprod Health. 2016;13(Suppl 2):111.

23 Kpokiri EE, John R, Wu D, et al. Crowdsourcing to develop open-access learning resources on antimicrobial resistance. BMC Infect Dis. 2021;21:1023. https://doi.org/10.1186/s12879-021-06628-0

24 Saez-Rodriguez J, Costello JC, Friend SH, et al. Crowdsourcing biomedical research: leveraging communities as innovation engines. Nat Rev Genet. 2016;17:470–86.

25 Federal Ministry of Health [FMOH]. Task-Shifting and Task-Sharing Policy for Essential Health Care Services in Nigeria. 2014. Available at: https://advancefamilyplanning.org/sites/default/files/resources/Nigeria%20taskshifting%20policy-Aug2014%20REVISEDCLEAN%20_Approved%20October%202014.pdf.

26 Mbouamba YB, Adeagbo O, Amu H, et al. Task shifting and task sharing in the health sector in sub-Saharan Africa: evidence, success indicators, challenges, and opportunities. Pan Afr Med J. 2023;46:11.

27 Oseni TIA, Olawumi AL, Salam TO, et al. The role of community health workers in the management of hypertension in Nigeria. BMC Prim Care. 2024;25(1):266.

28 Uzondu CA, Doctor HV, Findley SE, et al. Female health workers at the doorstep: a pilot of community-based maternal, newborn, and child health service delivery in northern Nigeria. Glob Health Sci Pract. 2015;3(1):97–108.

29 Awolude OA, Oyerinde SO, Akinyemi JO. Screen and triage by community extension workers to facilitate screen and treat: task-sharing strategy to achieve universal coverage for cervical cancer screening in Nigeria. J Glob Oncol. 2018;4:1–10.

30 Goff DA, Prusakov P, Mangino JE, et al. International train-the-trainer neonatal antibiotic stewardship program for South African pharmacists. J Am Coll Clin Pharm. 2021;4(12):1572–82.

31 Bajracharya KS, Luu S, Cheah R, et al. Mentorship advances antimicrobial use surveillance systems in low- and middle-income countries. JAC Antimicrob Resist. 2024;7(1):dlae212.

32 Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database Syst Rev. 2012;2012(6):CD000259.

33 Centre for Human and Professional Regulation in the Built Environment (CHPRBN). Standing Orders. Abuja, Nigeria: CHPRBN. Available at: https://chprbn.gov.ng/standingorders [accessed March 2, 2026].

34 Cohn J, Mendelson M, Kanj SS, et al. Accelerating antibiotic access and stewardship: a new model to safeguard public health. Lancet Infect Dis. 2024;24(9):e584–90.

35 Zacchaeus NGP, Palanikumar P, Alexander H, et al. Establishing an effective antimicrobial stewardship program at four secondary-care hospitals in India using a hub-and-spoke model. Antimicrob Steward Healthc Epidemiol. 2023;3(1):e99.

36 Tom-Aba D, Toikkanen SE, Glöckner S, et al. User evaluation indicates high quality of the Surveillance Outbreak Response Management and Analysis System (SORMAS) after field deployment in Nigeria in 2015 and 2018. Stud Health Technol Inform. 2018;253:233–7.

37 Nigeria Centre for Disease Control and Prevention [Internet]. Available at: https://ncdc.gov.ng/reports/weekly/2020/12/50.

38 Okeke IN, Peeling RW, Goossens H, et al. Diagnostics as essential tools for containing antibacterial resistance. Drug Resist Updat. 2011;14(2):95–106.

39 Olutuase VO, Iwu-Jaja CJ, Akuoko CP, et al. Medicines and vaccines supply chains challenges in Nigeria: a scoping review. BMC Public Health. 2022;22(1):11.

40 Liu J, Prach LM, Treleaven E, et al. The role of drug vendors in improving basic health-care services in Nigeria. Bull World Health Organ. 2016;94(4):267–75.

41 Adeloye D, David RA, Olaogun AA, et al. Health workforce and governance: the crisis in Nigeria. Hum Resour Health. 2017;15(1):32.

42 Udoh A, Akpan M, Ibrahim UI, et al. Clinical pharmacy services provided in public sector hospitals in Nigeria: a national survey. Int J Pharm Pract. 2021;29(5):471–9.

43 Iskandar K, Molinier L, Hallit S, et al. Surveillance of antimicrobial resistance in low- and middle-income countries: a scattered picture. Antimicrob Resist Infect Control. 2021;10(1):63.

© The Author(s) 2026. Published by Oxford University Press on behalf of Royal Society of Tropical Medicine and Hygiene. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (https://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site-for further information please contact journals.permissions@oup.com