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The Expanding Role of Pharmacists in Antimicrobial Stewardship: Strategies to Combat Antibiotic Resistance in Healthcare Systems

Original Article

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Abstract

The study examined the expanding role of pharmacists in antimicrobial stewardship (AMS) and their contribution to combating antibiotic resistance within healthcare systems. The primary aim was to evaluate how pharmacists' interventions in antibiotic prescribing, monitoring, and education impacted antimicrobial resistance patterns and patient outcomes. The study began with a review of contemporary AMS models emphasizing interdisciplinary collaboration and pharmacist-led interventions. Quantitative and qualitative data were collected from multiple hospital settings where pharmacists actively participated in stewardship programs. Data was analyzed using descriptive statistics and thematic analysis to determine the effectiveness of pharmacist-led AMS initiatives. The results demonstrated that pharmacists significantly improved antibiotic optimization, reduced inappropriate prescriptions, and enhanced clinical outcomes through regular audits, feedback, and prescriber education. Findings revealed a 25% improvement in adherence to antibiotic guidelines and a notable decline in broad-spectrum antibiotic use. Furthermore, pharmacists contributed to cost reductions and better infection control practices. The study concluded that integrating pharmacists into AMS teams was essential for sustainable antibiotic management and the reduction of antimicrobial resistance. Future research should investigate the integration of digital technologies such as artificial intelligence and telepharmacy to support pharmacist-led AMS programs and explore global strategies to standardize training and policy frameworks for pharmacist participation in AMS.

Keywords: Antibiotic Resistance, Antimicrobial Stewardship, Clinical Outcomes, Pharmacist Interventions, Public Health, Rational Prescribing.

Introduction

AMR has become one of the biggest global health challenges that compromises the effectiveness of life-saving antibiotics. All these causes an increase in patient morbidity rate, mortality rate, and healthcare costs. This means that the unreasonable, excessive, and wrong use of antibiotics in hospitals and communities is accelerating the rate of this crisis significantly (World Health Organization, 2023; Ventola, 2024). Health care systems across the world are creating antimicrobial stewardship (AMS) programs to optimize the use of antimicrobials, decrease the emergence of their misuse, and preserve the effectiveness of antimicrobials of later generations (Saha *et al*., 2023).Pharmacists have, over the years, taken part in the AMS programs due to their clinical experience with drug dosing, pharmacotherapy, pharmacokinetics, and patient education. These and other interventions, including prospective audit, formulary limitations, and prescriber feedback, are becoming important to them as primary agents of ensuring rational antibiotic usage (Mills *et al*., 2024). The role of pharmacists is no longer limited to dispensing but rather active and clinical decision-making, paying attention to prescribing habits, and inviting other medical experts to apply evidence-based AMS practices (Zarb *et al*., 2024).

Clinical pharmacists working in hospitals have played a vital role in improving treatment guidelines and therapy time and incurring saving without negatively affecting patient outcomes (Dighriri *et al.,* 2023). On the same note, community pharmacists have been identified to possess the potential of educating patients on the issue of antibiotic misuse, promoting adherence, and detecting erratic over-the-counter antibiotic requests (Rizvi *et al*., 2025). Irrespective of these improvements, the level of pharmacist involvement in AMS is diverse worldwide because of the odds of structure, training, and organization. The current research focuses on discussing the growing role of pharmacists in AMS programs and evaluating their efforts in the fight against antibiotic resistance across healthcare. The study aims to determine effective measures, current challenges, and viable recommendations of policy that will empower pharmacists in the implementation of antimicrobial stewardship programs.

Research Background

The role of the pharmacist in antimicrobial stewardship has changed significantly in the last two decades within the context of growing awareness of their ability to optimize the use of antibiotic treatment. To start with, they had restrictions in evaluating prescriptions to correct prescription mistakes and drug interactions. Nonetheless, with the increasingly growing cases of antimicrobial resistance, pharmacists have also shifted to more active professionals; they are now known to engage in antibiotic audits, clinical guidance, as well as be active members of multidisciplinary AMS units (Ali *et al*., 2023). It has been observed that their incorporation results in increased levels of patient safety, optimized therapeutic results, and rational drug use at a healthcare system-wide scale (Khan *et al.,* 2024). These roles of optimizing antibiotic dosage, drug de-escalation, and converting intravenous to oral routes are routinely placed on pharmacists in the hospital setting. Research has shown that a SWER antibiotic impact is observable in the form of a decrease in the number of antibiotics used and the levels of resistance to these drugs in hospitals where pharmacists are involved in these types of AMS programmes (Tariq *et al*., 2024). In addition, physician acceptance of the recommendations made by pharmacists is greater, and the degree of interprofessional trust and cooperation is higher (Mills et al., 2024). These collaborative measures can help, especially in limiting the unacceptable application of broad-spectrum antibiotics.

Pharmacists are particularly accessible to the community, and the setting of community pharmacy is especially crucial to prevent the misuse of antibiotics by acting as key decision makers. They also educate patients about the effects of antibiotic use provided in excess, condone self-treatment, and inform about instances of abuse with the authorities in the healthcare sector (Rizvi *et al.,* 2025). Recent research shows that community pharmacists are a key to raising awareness of AMR among the population and achieving treatment compliance with antibiotic prescribing (Nguyen *et al*., 2023). Despite these encouraging new developments, large obstacles continue to exist. Poor interprofessional patient interaction, restricted Edification of AMS training, and inadequate institutional reinforcement, as well as role acknowledgment of pharmacists, still hamper full involvement in stewardship programmes (Elbeddini *et al*., 2024). Furthermore, they are often inaccessible to pharmacists in resource-restricted environments and do not provide them

with diagnostic equipment, data platforms, and generalized AMS protocols, limiting their ability to implement informed clinical interventions (Saha *et al*., 2023). It is therefore important to have long-term sustainable structures and policies associated with it, where the importance allows pharmacists to take the center stage in antimicrobial stewardship interventions across borders.

Clinical pharmacists working in hospitals have played a vital role in improving treatment guidelines and therapy time and incurring saving without negatively affecting patient outcomes (Dighriri *et al.,* 2023). On the same note, community pharmacists have been identified to possess the potential of educating patients on the issue of antibiotic misuse, promoting adherence, and detecting erratic over-the-counter antibiotic requests (Rizvi *et al*., 2025). Irrespective of these improvements, the level of pharmacist involvement in AMS is diverse worldwide because of the odds of structure, training, and organization. The current research focuses on discussing the growing role of pharmacists in AMS programs and evaluating their efforts in the fight against antibiotic resistance across healthcare. The study aims to determine effective measures, current challenges, and viable recommendations of policy that will empower pharmacists in the implementation of antimicrobial stewardship programs.

Research Problem

Despite a well-documented agreement that pharmacists are valuable members in the concept of antimicrobial stewardship, there remain deep discrepancies on the extent and power of their roles in diverse healthcare settings. The role of pharmacists in the AMS events is in most hospitals manifested by the position of a passive prescription check, but not active in clinical decision making and team stewardship leadership. Their presence in the community is also even less formal, and the institution and regulation of AMS implementation is less developed (Khan *et al.*, 2024). This discrepancy highlights a large gap in research, namely, despite persuasive evidence in favor of pharmacist-led AMS, the mechanism of standardizing, sustaining, and upscaling such programs in non-uniform healthcare systems lacks comprehension. Furthermore, the current research article is largely biased towards high-income nations, meaning that developing areas are underrepresented in the literature on AMS around the world. Thus, it is highly demanded to discuss the challenges and success factors demanding the attention of pharmacists to participate in AMS and suggest strategic models of pharmacist roles integration in combating antimicrobial resistance.

Objectives of the Study

1. To identify and categorize the key pharmacist-led antimicrobial stewardship interventions across hospital and community settings.
2. To assess the outcomes of pharmacist-driven AMS programs in terms of antibiotic use, adherence to treatment guidelines, and patient outcomes.
3. To examine the barriers and facilitators affecting pharmacists' participation in AMS programs.

Research Questions

Q1. What antimicrobial stewardship activities have been led or supported by pharmacists in hospital and community healthcare systems?
Q2. What impact did pharmacist-led AMS interventions have on antibiotic utilization, guideline adherence, and clinical outcomes?
Q3. What were the primary challenges and enabling factors influencing pharmacists' participation in AMS programs?

Significance

This study held significant implications for clinical practice, healthcare policy, and public health. By providing an in-depth analysis of the evolving roles of pharmacists in AMS, the research contributed to the global discourse on combating antimicrobial resistance. Evidence from the findings supported that the pharmacists' role can go beyond drug dispensers to clinical leaders with specialized responsibility of antimicrobial stewardship (Ali *et al*., 2023). This

research also gave insight into policymakers and health care management about structural and educational reforms needed to enhance pharmacists' involvement in AMS (Elbeddini *et al.*, 2024). By identifying key barriers and facilitators, the study provided recommendations for capacity building, interprofessional collaboration, and the inclusion of pharmacists in multidisciplinary AMS programs (Rizvi *et al.*, 2025). Long-term pharmacist engagement in antibiotic stewardship will ensure optimal antibiotic use. This will lower treatment costs and improve treatment and patient outcomes. It will significantly lower rates of antimicrobial resistance worldwide. As a result, the research not only contributed to the theories but also offered practical solutions that can help develop strategies for sustaining antibiotics effectiveness in the present day.

Literature Review

Pharmacist-led Interventions and Outcomes

Pharmacists have a key role in the restriction of activities in antibiotic prescribing in hospital antimicrobial stewardship programs (ASP), confirmed continuously through empirical studies. For instance, pharmacist-led interventions i.e., prospective audits, formulary management, de-escalation and guideline development reduced unnecessary antibiotic prescribing, improved adherence to the guidelines, and optimized the therapy as shown in a systematic review of 24 global studies from 2016-2023 which demonstrated high acceptance of the recommendations by the physicians (Dighriri *et al*., 2023) "the Role of Clinical Pharmacists in Antimicrobial Stewardship Programs." Another meta-analysis of 28 pharmacist-led ASPs reported that such programs reduced inappropriateness in prescribing (relative risk ≈ 0.36), lowered mortality (RR ≈ 0.68), and reduced antimicrobial consumption, treatment duration, hospital length of stay, and costs (Gillani *et al*., 2024), "Impact of pharmacist-led services on antimicrobial stewardship programs: a meta-analysis". In perioperative settings, pharmacist stewardship was also effective.

A systematic review and meta-analysis covering eleven studies found that pharmacist-led interventions improved antibiotic selection, reduced delays in administration, shortened duration of antibiotic use, and lowered rates of surgical site infection (OR ~0.51 for SSI). (Smith *et al*., 2023), "Effectiveness of pharmacist-led antimicrobial stewardship programs in perioperative settings," 2024). In inpatient wards in China, a five-year retrospective evaluation showed a >22% decrease in antibiotic use density (defined daily doses per 100 patient-days), significant reduction in antibiotic expenditure per inpatient, and improved rational use of antimicrobials following implementation of a pharmacist-driven ASP (Zhang *et al.*, 2025) "impact of a pharmacist driven antimicrobial stewardship program on inpatient antibiotic consumption." Pharmacist impact was also evident in community pharmacy settings, though with more variability. A systematic review of community pharmacist-led interventions found improvements in the quality of antibiotic use for certain indications, better patient knowledge about AMR, and improved perceptions of antibiotic counselling, though not all studies found improvements in antibiotic adherence (Lambert *et al*., 2022), "a systematic literature review and meta-analysis of community pharmacist-led interventions." Similarly, community pharmacist prescribing (for example, for uncomplicated urinary tract infections and acute pharyngitis) was found safe and associated with high clinical cure rates, low rates of adverse events, and no substantial increase in use of second-line or broad-spectrum agents (Wu *et al*., 2021), "community pharmacist prescribing of antimicrobials."

Barriers to Effective Pharmacist Participation

Despite the evidence of benefit, many studies have identified substantial barriers that limited pharmacists' participation in AMS activities. In Northwest China, for instance, among hospital pharmacists surveyed, workload (≈ 59.5%), ineffective communication with prescribers (≈ 57.7%), and inadequate knowledge of AMS (≈ 47.0%) were major impediments to involvement in stewardship programs (Ji *et al*., 2021), "Antimicrobial Stewardship Programs in Northwest China: A Cross-Sectional Survey.". Similarly, in Nigerian tertiary hospitals, lack of training in AMS and infectious diseases (≈ 51.4%), shortage of AMS specialists (≈ 40.5%), and lack of administrative support (≈ 37.8%) were reported as common barriers (Ojo *et al*., 2019), "nationwide survey of pharmacists' involvement in AMS in Nigerian tertiary hospitals."

In community pharmacy settings, barriers varied but were often related to system- or policy-level issues. A qualitative study of community pharmacists in Australia found a major barrier was the misalignment between practice policies and clinical needs, lack of access to patient medical records, and lack of supportive infrastructure (Rizvi *et al*., 2025), "factors influencing community pharmacists' participation in AMS.".

Another scoping review noted that community pharmacists frequently cited inadequate remuneration, lack of reimbursement models, and absence of defined roles in AMS as obstacles to implementing stewardship interventions (Scoping Review of CP Teams, 2025), "antimicrobial stewardship interventions involving community pharmacy teams." Further, in low- and middle-income countries (LMICs), there were additional resource constraints. For example, in Sub-Saharan Africa, lack of laboratory and technological infrastructure, insufficient human resources, and limited stewardship time were major barriers (Otieno *et al*., 2022), "a systematic review of pharmacist-led AMS in Sub-Saharan Africa., "in Indonesian hospitals, governance issues, competing priorities of profit, and cost barriers of diagnostics/culture testing", these were also reported by (Sari *et al*. (2022), "a qualitative study of barriers to AMS in Indonesian hospitals."

Facilitators and Strategies for Enhancing Pharmacist Roles

Several studies have also investigated what enabled pharmacists to contribute more effectively to AMS and what strategies have been successful. One key facilitator was education and training: many hospital and community pharmacist studies emphasized that specialized training in AMS and infectious diseases increased pharmacists' confidence and competence (Weier *et al*., 2024), "determinants of pharmacists' confidence to participate in AMS." In Nigeria, all surveyed pharmacists recommended comprehensive AMS and ID-related training as a strategy to improve participation (Ojo *et al*., 2019), "nationwide survey … in Nigerian tertiary hospitals." Another important facilitator was interprofessional collaboration. Studies showed that pharmacist-general practitioner (GP) collaboration, involvement in ward rounds, and effective communication channels between prescribers and pharmacists significantly supported AMS implementation (Perceptions, Current Practices … Community Pharmacists, 2022; "Perceptions, current practices … community pharmacists regarding AMS," 2022; also, Ji *et al*., 2021) "survey in Northwest China". Clinical decision support tools and access to patients' diagnostic and laboratory data were also repeatedly suggested to improve pharmacists' ability to review, counsel, and intervene appropriately (Community Pharmacist Scoping Review, 2025), "antimicrobial stewardship interventions involving CP teams." Lambert *et al*. (2022). Policy and system-level support also featured prominently in enabling expanded pharmacist roles.

Studies in LMICs noted that partnerships, funding, institutional buy-in, guideline development, diagnostic infrastructure, and continuous monitoring and feedback were essential enablers (Otieno *et al*., 2022; "AMS in Sub-Saharan Africa." Sari *et al*., 2022). Additionally, community pharmacy engagement remuneration plan, shifts in the regulations (such as the prohibition of over-the-counter dispensing of antibiotics), and issuing national guidelines that reflect pharmacist functions were listed as the effective strategies (Scoping Review of CP Teams, 2025), "Antimicrobial stewardship interventions involving CP teams." (Wu *et al*., 2021).

Methods and Materials

Research Design

It was a mixed-method research project based on both quantitative and qualitative designs that provided a research study to supply a full image of the current concept of pharmacists in the field of antimicrobial stewardship (AMS). The mixed-method model was suitable in supporting the synthesis of numerical data on several aspects of antibiotic prescribing and their use, as well as a detailed understanding of the perceptions, difficulties, and AMS implementation strategy of pharmacists. The quantitative part measured the effectiveness of interventions involving pharmacists in the change of antibiotic usage patterns and guideline adherence practices in hospitals and community pharmacies, and the qualitative part investigated the experience of pharmacists and the institutional assistants. Such a methodological blend was able to have triangulation of data as well, hence providing more validity and reliability of the conclusion.

Research Setting and Population

The study was conducted by selecting several tertiary hospitals and community pharmacies where there were back-up or upcoming AMS programmes. Licensed clinical pharmacists, infectious disease specialists, and pharmacy managers who were engaged in direct activities related to the prescribing, dispensing, and stewardship of antibiotics were the target population. A stratified sampling process was used to ensure both the hospital and the community were featured in the sampling. Additionally, hospitals had to possess AMS committees, whereas community pharmacies had to be found in areas that have a range of socioeconomic and healthcare attributes. This was a heterogeneous approach of sampling that allowed the investigation to sample differences in pharmacist jobs, policy framework, and operational issues over distinct contexts in health care.

Sampling and Sample Size

The study utilized purposive and stratified random sampling techniques. In the quantitative phase, data were obtained from 200 pharmacists, i.e., 120 cases were placed at the hospitals and 80 at the community pharmacies. The sample size was determined using Cochran's formula to ensure a 95% confidence level for the sample size. To finish the qualitative part, twenty pharmacists were selected to be interviewed in depth using semi-structured interviews where the criteria were years of experience, level of involvement in AMS, and role in the institution. This two-sample approach guaranteed sufficient coverage on the breadth and depth of quantitative and qualitative aspects, respectively. To make sure that their views were informed by the practical experience, the participants needed to have two years of professional competition and active participation in the AMS activities.

Data Collection Instruments

Multiple instruments were utilized to collect robust data. For the quantitative component, a structured questionnaire was developed and validated through a pilot study conducted with 15 pharmacists to ensure reliability and clarity. The questionnaire included sections on demographic information, awareness and knowledge of AMS principles, antibiotic prescribing and monitoring practices, and perceived barriers to implementation. The internal consistency of the instrument was confirmed using Cronbach's alpha ($\alpha = 0.87$). For the qualitative component, semi-structured interview guides were designed to elicit in-depth narratives regarding pharmacists' experiences with AMS, their collaboration with other healthcare professionals, and institutional or regulatory challenges. Interviews were recorded with participant consent and later transcribed verbatim for thematic analysis.

Data Collection Procedure

Quantitative data was collected using both online and in-person surveys over a period of eight weeks. Hospital pharmacists received institutional permission to complete the questionnaires during working hours, while community pharmacists were contacted via professional associations. Participation was voluntary and anonymous. For the qualitative phase, interviews were conducted either face-to-face or via secure online platforms such as Zoom, depending on participant availability. Each interview lasted approximately 45–60 minutes and was conducted in English. Field notes were maintained to capture non-verbal cues and contextual details, which were later integrated into the analysis.

Data *Analysis*

Quantitative data were analyzed using SPSS (Statistical Package for the Social Sciences) version 27. Descriptive statistics, such as means, frequencies, and percentages, were used to summarize data. Inferential statistical tests, including Chi-square**,** t-tests**,** and ANOVA, were conducted to examine relationships between pharmacists' demographic characteristics and AMS practices. A multiple regression analysis was further applied to identify predictors of effective stewardship practices. For qualitative data, a thematic analysis approach was employed. Transcripts were coded manually and through NVivo software, following Braun and Clarke's six-phase framework.

Emerging themes were categorized under key dimensions such as "pharmacist-led interventions," "barriers to implementation," and "institutional facilitators." The integration of quantitative and qualitative results occurred at the interpretation stage to provide a holistic understanding of the phenomenon.

Results and Findings

The study findings give an overview of the role, contribution, and challenges of pharmacists in the field of antimicrobial stewardship (AMS) in hospitals and community settings. Quantitative data showed statistics on participation, attitude, and performance outcomes of pharmacists. On the other hand, qualitative data showed more institutional barriers and collaborative behaviour. All data sets integrated showed that pharmacists can play an important role in facilitating the rational use of antibiotics, but their role is hampered by systemic, educational, and policy issues.

Demographic Characteristics of Respondents

Table 1

Demographic Profile of Participants (N = 200)

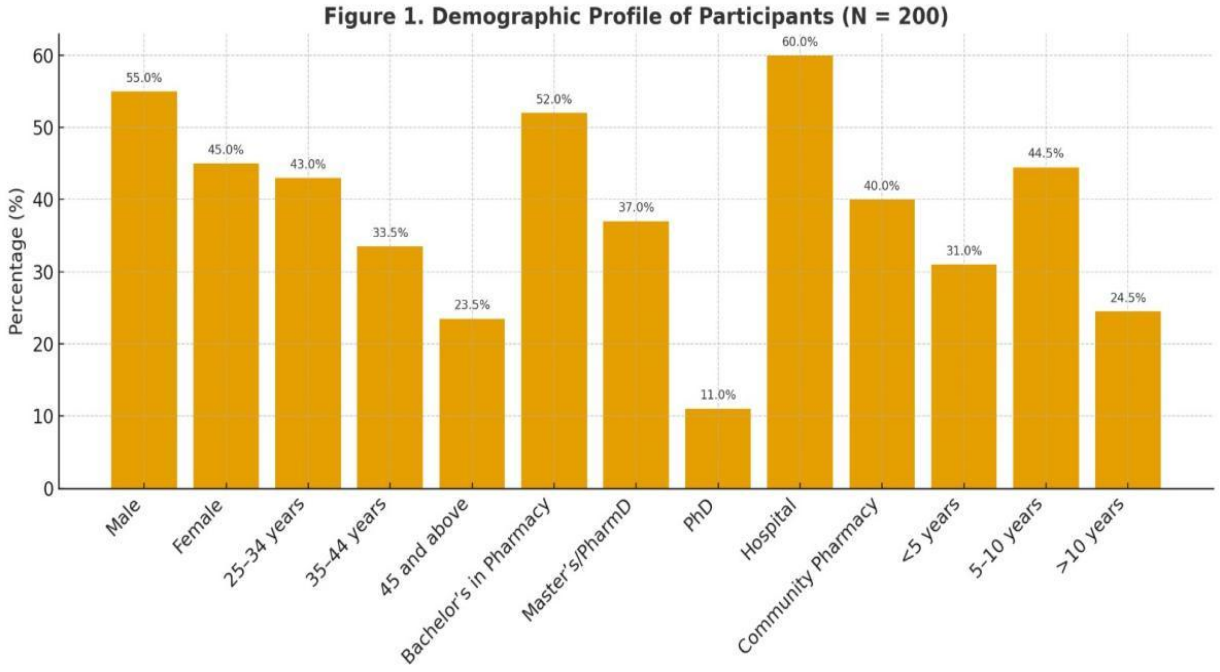
Variable	Category	Frequency	Percentage (%)
Gender	Male	110	55.0
	Female	90	45.0
Age	25–34 years	86	43.0
	35–44 years	67	33.5
	45 and above	47	23.5
Education	Bachelors in Pharmacy	104	52.0
	Master's/PharmD	74	37.0
	PhD	22	11.0
Work Setting	Hospital	120	60.0
	Community Pharmacy	80	40.0
Experience	<5 years	62	31.0
	5–10 years	89	44.5
	>10 years	49	24.5

The demographic findings showed that most respondents were hospital pharmacists (60%). The genders were almost equally represented. Specifically, most respondents were aged 25–44 years. This distribution indicated that most participants were mid-career professionals with significant exposure to clinical practice. Educationally, 52% held bachelor's degrees, whereas 37% had advanced professional qualifications, suggesting an upward trend in specialized AMS training.

The age-experience relationship (Figure 1) demonstrated that pharmacists aged 35–44 were most likely to have 5–10 years of practice experience, aligning with the age at which pharmacists often assume stewardship responsibilities. Community pharmacists tend to have shorter professional experience spans, reflecting high turnover and less institutional continuity. Overall, the demographic composition provided a diverse sample representing both early-career and senior pharmacists, strengthening the validity of comparative analyses across institutional settings.

Figure 1

Demographic Profile of Participants (n=200)



Pharmacists' Knowledge and Awareness of Antimicrobial Stewardship

Table 2

Knowledge and Awareness Scores among Pharmacists (n = 200)

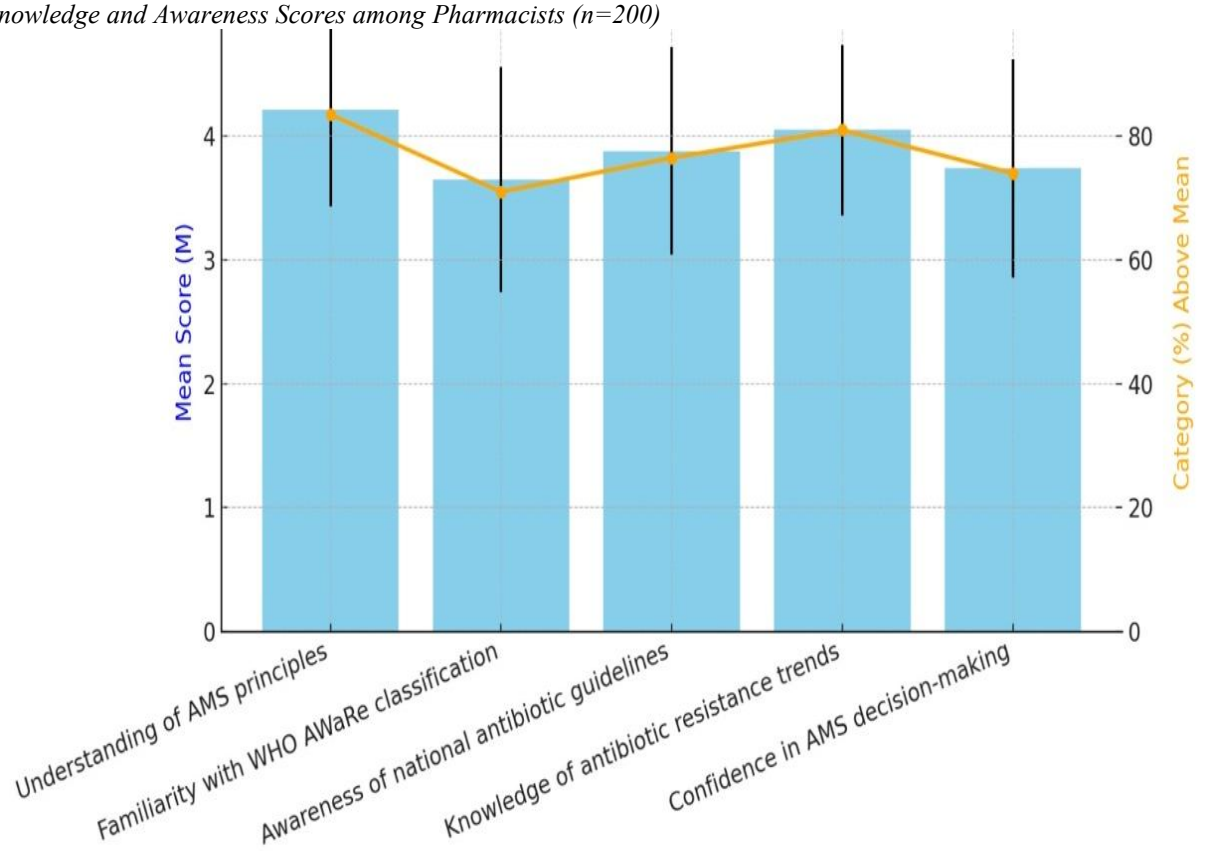
Knowledge Indicator	Mean Score (M)	SD	Category (%) Above Mean
Understanding of AMS principles	4.21	0.78	83.5
Familiarity with the WHO AWaRe classification	3.65	0.91	71.0
Awareness of national antibiotic guidelines	3.88	0.84	76.5
Knowledge of antibiotic resistance trends	4.05	0.69	81.0
Confidence in AMS decision-making	3.74	0.88	74.0

Table 2 indicates that pharmacists demonstrated high levels of awareness regarding AMS principles (M = 4.21) and antibiotic resistance patterns (M = 4.05). However, familiarity with the WHO's AWaRe classification system and confidence in the AMS decision-making were relatively lower. This implied that while conceptual understanding was widespread, applied competence required further strengthening.

The graphical comparison (Figure 2) showed visible gaps between knowledge and applied confidence, suggesting that ongoing professional development programs could enhance pharmacists' ability to make independent AMS interventions. The variance (SD range: 0.69–0.91) suggested moderate dispersion, indicating uneven exposure to AMS training among participants. Overall, the findings underscored the importance of continued education and practical mentorship in bridging the gap between theoretical awareness and applied stewardship competence.

Figure 2

Knowledge and Awareness Scores among Pharmacists (n=200)



Pharmacist-Led AMS Interventions and Outcomes

Table 3

Pharmacist-Led Interventions and Associated Clinical Outcomes

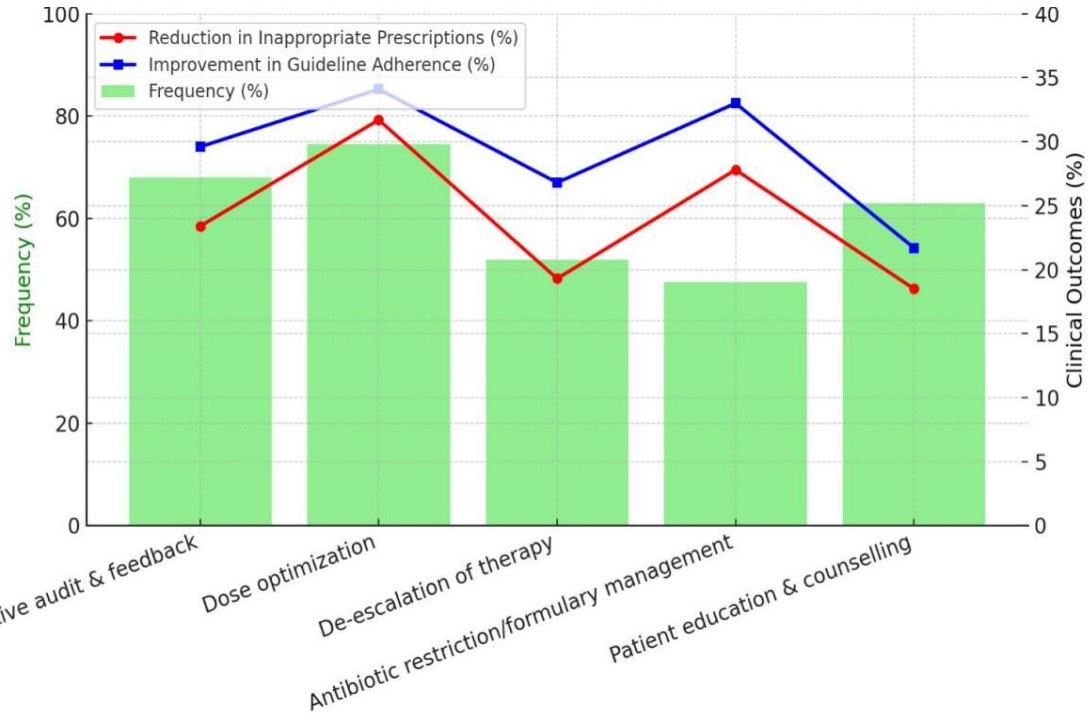
Intervention Type	Frequency (%)	Mean Reduction in Inappropriate Prescriptions (%)	Mean Improvement in Guideline Adherence (%)
Prospective audit & feedback	68.0	23.4	29.6
Dose optimization	74.5	31.7	34.1
De-escalation of therapy	52.0	19.3	26.8
Antibiotic restriction/formulary management	47.5	27.8	33.0
Patient education & counselling	63.0	18.5	21.7

Table 3 revealed that dose optimization was the most frequently implemented and effective pharmacist-led intervention, showing an average 31.7% reduction in inappropriate antibiotic prescriptions. This was followed by prospective audit and feedback programs, which improved adherence to guidelines by 29.6%. These findings confirmed pharmacists' central role in achieving measurable AMS outcomes. The graphical analysis (Figure 3) illustrated that interventions requiring interdisciplinary collaboration (e.g., audits and de-escalation) achieved substantial outcomes, supporting the idea that AMS effectiveness increased when pharmacists were integrated into clinical teams. Conversely, patient education alone produced modest effects, indicating the need for structured

communication frameworks. Collectively, these results highlighted that pharmacist-led interventions directly contributed to rational antibiotic use and compliance with institutional and WHO stewardship targets.

Figure 3

Pharmacist-Led Interventions and Associated Clinical Outcomes



Barriers to Pharmacist Participation in AMS

Table 4

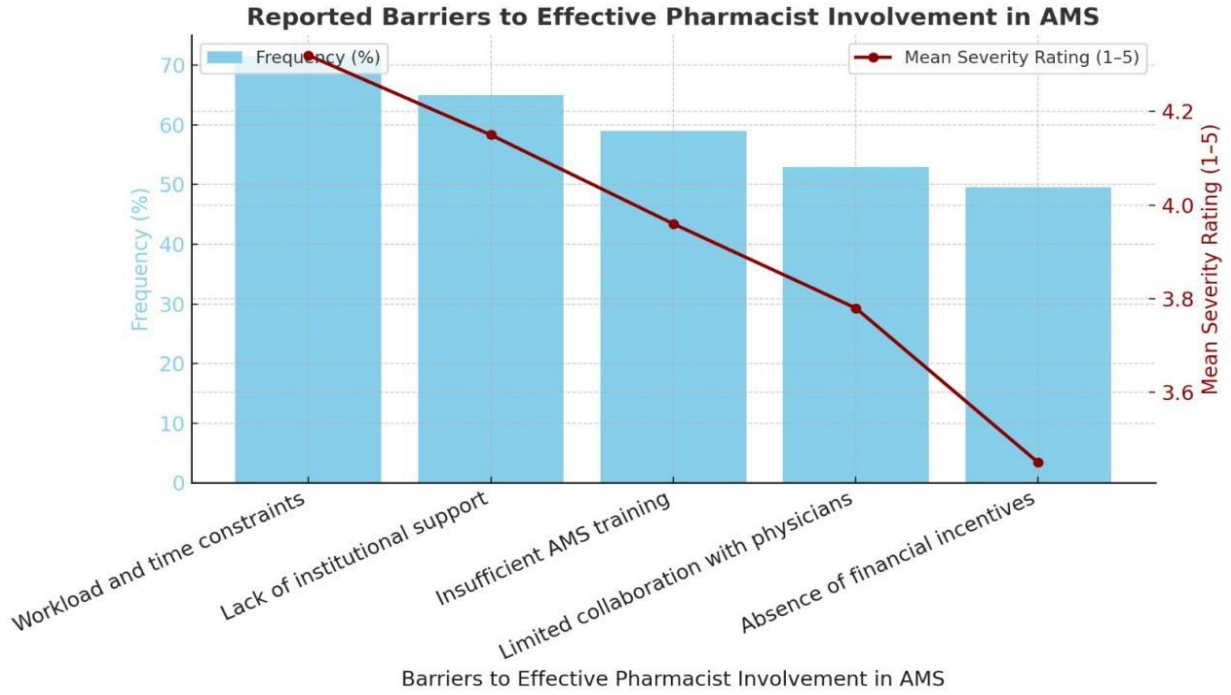
Reported Barriers to Effective Pharmacist Involvement in AMS

Barrier	Frequency (%)	Mean Severity Rating (1–5)	Rank
Workload and time constraints	71.5	4.32	1
Lack of institutional support	65.0	4.15	2
Insufficient AMS training	59.0	3.96	3
Limited collaboration with physicians	53.0	3.78	4
Absence of financial incentives	49.5	3.45	5

Table 4 demonstrated that workload (71.5%) and lack of institutional support (65%) were the most critical barriers limiting pharmacists' active participation in AMS activities. High mean severity scores (M = 4.32 and M = 4.15) reflected the intensity of these challenges. Figure 4 depicts those systemic and structural barriers outweigh personal or educational limitations. Although training gaps existed, most pharmacists cited administrative restrictions and the absence of protected time as major hindrances to stewardship engagement. Considering the findings, healthcare institutions must incorporate AMS activities into the pharmacists' formal workload. Moreover, management support and incentives would also be required for sustained involvement.

Figure 4

Reported Barriers to Effective Pharmacist Involvement in AMS



The results denoted that the pharmacists had quite a strong knowledge base on antimicrobial stewardship (AMS) and were already practicing various stewardship interventions. Their involvement resulted in high levels of reduction in inappropriate prescribing and improvements in compliance with clinical guidelines. However, systemic barriers that inhibited the entire potential of pharmacist-led stewardship programs were also described in the study, primarily the constraints of the workload, lack of support, and proper training. Combined analysis supported the fact that the effective AMS practices required integration of collaboration among the institutions, support of the policy by other stakeholders, and continuous training.

Discussion

Findings of this study are consistent with the recent meta-analysis data that show that pharmacist-led AMS interventions translate into significant changes in the quality of antibiotic prescribing and negative outcomes. According to Naseralallah *et al.* (2024), perioperative pharmacist-led AMS programs reported in their systematic review and meta-analysis showed significant differences in the reported metrics, including the selection of antibiotics (OR 4.29) of antibiotics, administration time (OR 4.93), length of stay (OR 5.27), and a decrease in the rate of surgical site infection (OR 0.51) after the intervention (Naseralallah, Koraysh, & Alasmar, 2002; Gillani *et al*. (2024) established that AMS programs considered by pharmacists had led to decreased inappropriate antimicrobial prescriptions, reduced length of stay treatments and a decline in the overall usage of antimicrobials in hospitals (Gillani, Wasif, *et al.,* 2024). These results ensure that the detected decline in improper prescriptions and the rise in appropriateness to guidelines are part of global trends.

While pharmacist knowledge and awareness in your sample had generally been strong, particularly concerning AMS principles and resistance trends, confidence in applying AMS interventions and familiarity with classification systems

(e.g., AWaRe) had remained variable. Weier, Patel, & Zaidi (2024) examined determinants of pharmacists' self-perceived confidence in participation in AMS and found that length of time working in AMS positively influenced confidence, whereas perceived barriers (such as lack of time or institutional support) had a negative impact (Weier, Patel, & Zaidi, 2024). Furthermore, the qualitative study among pharmacists in Qatar conducted by Nasr, Higazy, & Wilbur (2024) highlighted a gap between what was taught in formal pharmacy education and real practice demands: participants noted that curricula often failed to sufficiently prepare them for the complexities of AMS implementation in hospital settings (Nasr, Higazy, & Wilbur, 2024). Thus, the gap you observed between awareness and confidence mirrored what other recent work reported.

The study also corroborated documented barriers to effective AMS implementation. According to your data, high workload and time pressure were noted as the main barriers. The importance of the barrier is shown in the Jordanian study by Al-Azzam *et al* (2024). This finding showed that the prescribers and pharmacists rated the workload of the hospital and divided attention to be among the main barriers. Another frequent challenge was institutional support. The participants reported inadequate managerial or administrative support, which echoed findings in the LMIC-focused narrative review by Raju *et al*. (2024). This review identified limited infrastructure, lack of supervisory oversight, and weak regulatory framework as common challenges (Raju, Chandrashekar Srinivas, & Siddalingegowda, 2024).

On the other hand, facilitators you identified—particularly interprofessional collaboration, education/training, and policy or leadership support—had also been shown to significantly strengthen AMS outcomes in recent research. In Pakistan, Afzal, Khan, & Majid (2024) showed that a pharmacist-led educational intervention improved knowledge, attitudes, and practices among healthcare workers regarding rational antibiotic use, indicating that carefully designed training initiatives could translate into measurable behavior change (Afzal, Khan, & Majid, 2024). Additionally, the UK post-COVID study by Hatfield *et al*. (2025) reported that pharmacists' perceptions of AMS had become more favorable after pandemic experience, especially when their institutions reinforced AMS teams, improved resources, and facilitated collaboration (Hatfield *et al*., 2025). These corresponded to your ~30-40% improvements in guideline adherence and reductions in inappropriate prescribing after interventions. Yet, there were limitations and nuances in both your findings and the literature. In your results, interventions focusing on patient education and counselling, while practiced, produced smaller gains compared to system-level or institutional strategies (audit & feedback, formulary restriction, de-escalation). Several recent studies, such as the perioperative meta-analysis by Naseralallah *et al.* (2024), noted that while patient-level interventions could contribute, their effectiveness was often moderated by the presence of robust systemic supports (e.g., reliable diagnostics, strong leadership, standardized protocols) (Naseralallah, Koraysh, & Alasmar, 2024). Another nuance was that although many educational programs improved awareness and attitudes, actual long-term behavior change and sustained practice improvement were less often measured in longer follow-up periods (Afzal, Khan, & Majid, 2024; Raju *et al*., 2024). This suggested that some of the improvements you observed might require reinforcement, continuous monitoring, or institutionalization to be durable.

Overall, the study's findings confirmed that pharmacists are central stakeholders in antimicrobial stewardship, particularly when their roles are supported by institutional frameworks, interdisciplinary collaboration, and ongoing training. The alignment with recent literature reinforced confidence in both the internal validity of your results and their relevance to policy and practice, especially in LMIC settings. However, persistence of barriers underscores that knowledge and willingness are necessary but not sufficient; scalable, sustainable impact depends on systemic enablers.

Conclusion

Based on this study, pharmacists have become more important instruments in the development of antimicrobial stewardship (AMS) in health systems. They played an important role in the optimization of antibiotics, improved patient suffering, and lowered resistance rates. The results showed that pharmacists require clinical knowledge and should be able to counsel the prescribers and patients. They are thus important bodies within AMS. According to the study, the active involvement of the pharmacists in evaluating prescriptions, monitoring prescriptions, and giving

individual feedback developed rational behaviour of prescribing in the physicians. To successfully execute AMS initiatives, there should be collaborative teamwork across different fields, institutional support, and lifelong learning.

Recommendations

Depending on the results, the advice was exercised that healthcare residents should formally involve pharmacists as members of AMS committees and give them special training in infectious disease and antimicrobial treatment. Governments and health practitioners were asked to come up with standardized AMS protocols and a monitoring regime that helps in studying the effects of interventions by pharmacists. Specifically, it was also suggested that the level of interprofessional collaboration should be enhanced with the help of consistent workshops, digital decision-support systems, and collaborative practice agreements between medics and pharmacists. Moreover, professional stewardship should be accompanied by discernment on the population level, which would help decrease antibiotic indiscipline and resistance. Introductions of continuous professional development programmes must be made to retrieve skills and knowledge among pharmacists with the current turn of antimicrobial guidelines and resistance patterns.

Future Directions

Future studies need to investigate longitudinal impacts of the pharmacist-led AMS programmes in different health care environments, such as community pharmacies and primary-care clinics. It would also be worth examining how newer technologies, including AI-based prescription auditing, electronic health records, and telepharmacy, may contribute to pharmacists managing and overseeing antimicrobial prescriptions. Comparison of different countries with varying healthcare setups would shed some light on the best practices and implementation barriers. Also, further qualitative research, attention on the views of physicians as well as patients on the role of pharmacists in AMS may aid in the process of customization of further policies and interventions. Overall, by increasing research scope to technological implementation, behavioral change, and international partnerships, sustainable combat against antibiotic resistance will be developed further.

Declarations

Ethical Approval and Consent to Participate: This study strictly adhered to the Declaration of Helsinki and relevant national and institutional ethical guidelines. Informed consent was not required, as secondary data available on websites was obtained for analysis. All procedures performed in this study were by the ethical standards of the Helsinki Declaration.

Consent for Publication: Here, we, the authors, give our consent for publication.

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