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# Implementing Effective Antimicrobial Stewardship: Pharmacist-Led Strategies Across Healthcare Environments

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**ABSTRACT**

Antimicrobial resistance (AMR) poses a significant threat to public health, with projections indicating that AMR-related deaths could reach 10 million annually by 2050 without intervention. Antimicrobial stewardship (AMS) programs have been established to promote the appropriate use of antimicrobials and combat AMR. Pharmacists play a crucial role in these programs, contributing their expertise in various healthcare settings, including hospitals, long-term care facilities, and community pharmacies. This article explores the pharmacist's role in AMS activities, focusing on clinical interventions and adherence to regulatory standards. Pharmacists optimize antimicrobial use through strategies such as prospective audit and feedback, infection prevention, education, and public engagement. They collaborate with infectious disease physicians and other healthcare professionals to ensure appropriate antimicrobial selection, dosing, and duration of therapy. Pharmacists also contribute to reducing inappropriate antimicrobial use during transitions of care and in outpatient and long-term care settings. Regulatory bodies now mandate AMS programs in hospitals and nursing facilities, recognizing pharmacists as essential members of AMS teams. Pharmacists are well-positioned to ensure compliance with accreditation requirements and promote interdisciplinary collaboration to achieve AMS goals. Despite challenges such as limited resources and the need for specialized training, pharmacists play a vital role in optimizing antimicrobial use, improving patient outcomes, and mitigating the development of AMR.

**KEYWORDS:** Antimicrobial Stewardship, Pharmacist, AMS.

## 1. Introduction

Antimicrobial resistance (AMR) is an escalating threat to public health (Akpan et al., 2016), with projections indicating that, without intervention, AMR-related deaths could rise to 10 million annually by 2050 (Resistance, 2016). While the development of AMR is a natural biological process, the misuse and overuse of antimicrobials

have significantly accelerated resistance, resulting in the emergence of highly resistant pathogens in both community and hospital settings (Garau et al., 2014). Inadequate or inappropriate antimicrobial regimens are linked to adverse outcomes, including increased mortality, treatment failures, higher healthcare costs, prolonged durations of antimicrobial therapy, and extended hospital stays (Dalfino et al., 2014; Ortega et al., 2013; Spoorenberg et al., 2014).

The limited pipeline for new antimicrobial agents intensifies reliance on existing therapies, emphasizing the critical need for their preservation and responsible use. Recommendations to combat AMR and safeguard the efficacy of current antimicrobials have been proposed by the 2016 high-level meeting of the United Nations General Assembly on AMR and the final report from the Review on Antimicrobial Resistance in 2016.

Stewardship, in its broadest sense, is defined as the “careful and responsible management of something entrusted to one’s care”. When applied to antimicrobials—comprising antibiotics, antivirals, and antifungals—healthcare professionals are tasked with ensuring their responsible use, striking a balance between achieving optimal effectiveness and minimizing the risks of resistance and toxicity. Infectious diseases (ID) physicians and pharmacists are central to antimicrobial stewardship (AMS) teams, serving as key advocates for the appropriate use of antimicrobials (Barlam et al., 2016). The AMS strategies employed by pharmacists depend on the resources and level of care available but may include interventions such as converting intravenous antibiotics to oral forms, conducting prospective audits with interventions and feedback, optimizing dosing through pharmacokinetics and pharmacodynamics, implementing rapid diagnostic testing, and requiring pre-authorization for antibiotic use (Barlam et al., 2016).

Pharmacists are uniquely positioned to develop protocols and procedures aimed at enhancing antimicrobial use, given their regular involvement in multidisciplinary teams and committees. Their expertise is utilized across various settings, including inpatient care, ambulatory care, and long-term care facilities. Since antimicrobials are prescribed in all these contexts, pharmacists, as medication experts, are ideally placed to optimize these regimens as part of the patient care team. This article delves into the pharmacist’s critical role in AMS activities within inpatient and long-term care settings, focusing on clinical interventions and adherence to regulatory standards for AMS.

## Achieving Antimicrobial Stewardship Goals

The primary and secondary goals of AMS are broadly categorized to guide stewardship efforts. The primary goals include optimizing patient outcomes, preventing the emergence of antimicrobial resistance, and minimizing adverse events associated with antimicrobial use, which benefit both individual patients and society. Overemphasis on cost reduction alone can lead to the selection of suboptimal or more toxic antimicrobials, potentially increasing hospital stays, the risk of adverse effects, and the likelihood of unresolved infections. Pharmacists can support both primary and secondary AMS outcomes through regular reviews of antimicrobial regimens (Barlam et al., 2016).

Four key aspects of antimicrobial regimens are examined during reviews: diagnosis, drug choice, dosing, and duration of therapy. By optimizing these elements, stewardship efforts can reduce the duration of antimicrobial use, avoid unnecessary antimicrobials, and enhance patient outcomes while also achieving cost savings (Barlam et al., 2016).

To address antimicrobial resistance (AMR), antimicrobial stewardship (AMS) programmes have been successfully established in numerous countries at national, regional, and local levels. However, many resource-limited nations continue to face challenges in implementing AMS initiatives (Goff & Rybak, 2015). For further insights into the challenges and successes of AMS programmes, readers can refer to the Global Antimicrobial Stewardship; Challenges and Successes from Frontline Stewards supplement published in Infectious Diseases and Therapy (Infect Dis Ther, 2015; 4[Suppl 1]:1–83). AMS programmes adopt an organizational or system-wide approach to promoting and monitoring the appropriate selection, dosing, administration route, and duration of antimicrobial treatments, ensuring their sustained efficacy (Dellit et al., 2007; Fishman et al., 2012). While AMS strategies differ across countries (Bishop, 2016; Howard et al., 2015), there is a consensus that a multidisciplinary AMS team should include an infectious disease (ID) specialist, a hospital pharmacist, and a clinical microbiologist, all possessing expertise and professional involvement in infection diagnosis, prevention, and treatment (Dellit et al., 2007).

Pharmacists play a vital role in AMS programmes by developing and managing antimicrobial guidelines, optimizing individual patient therapies, educating healthcare professionals on antimicrobial stewardship, and monitoring and auditing antimicrobial usage outcomes (Gilchrist et al., 2015). This article seeks to explore the role of pharmacists in AMS programmes and their contributions to pharmacist-driven AMS strategies in hospital and community settings.

## Role of Pharmacists in AMS Programmes

Pharmacists are integral members of AMS teams and are actively involved in antimicrobial management (Gilchrist et al., 2015). Studies show that AMS programmes with a dedicated ID pharmacist achieve higher adherence to recommended antimicrobial therapy guidelines compared to those relying on general ward pharmacists (Bessesen et al., 2015). Specialized training, such as ID-focused residency and fellowship programmes, is the most widely recognized pathway for equipping pharmacists for AMS roles. Other training options include certifications offered by the Society of Infectious Disease Pharmacists, Making a Difference in Infectious Diseases Pharmacotherapy programmes, and professional development courses (Crader, 2014; Sneddon et al., 2015). However, budget constraints, staffing shortages, and the limited availability of ID-trained pharmacists hinder the widespread implementation of robust AMS programmes in some hospitals (Crader, 2014; Falcione & Meyer, 2014).

Given the scarcity of ID-trained pharmacists, the contributions of non-ID pharmacists to AMS programmes are increasingly recognized as essential (Messina et al., 2015). To address this gap, alternative AMS training opportunities are being extended to general pharmacists. For example, one study demonstrated that including

an introductory AMS elective course in a PharmD curriculum, which utilized active learning and human patient simulation technology, enhanced students' awareness, knowledge, and skills related to AMS (Falcione & Meyer, 2014). Students enrolled in this elective were expected to: (1) understand the principles and functions of AMS programmes, (2) develop and adjust patient-specific treatment plans for complex ID cases, and (3) apply AMS knowledge and resources (e.g., interpreting antibiograms, evaluating pharmacological and safety data) to propose strategies and criteria for healthcare institution drug formularies.

Another study highlighted the benefits of a mentoring programme, where experienced ID physicians and pharmacists provided mentorship, insights, and guidance, offering general pharmacists a valuable perspective gained from practical experience (Goff et al., 2017).

## Opportunities for Pharmacist-Driven AMS Strategies in Hospital and Community Settings

Pharmacists can significantly contribute to reducing inappropriate antimicrobial use through a variety of AMS strategies, including optimizing prescribing practices, monitoring antimicrobial use, preventing infections, and engaging in education, training, and public outreach.

### Optimizing Prescribing Practices and Monitoring Antimicrobial Use

A considerable portion of pharmacists' efforts is dedicated to improving prescribing behavior and overseeing antimicrobial use (Gilchrist et al., 2015). Antimicrobial prescription surveillance systems, which review patient clinical information to ensure ongoing treatment remains appropriate, have shown substantial financial and clinical benefits for hospitals (Nault et al., 2017). A Cochrane review demonstrated the effectiveness of restrictive or enabling interventions in increasing adherence to antimicrobial policies and reducing treatment durations (Goff et al., 2017). Automated, pharmacist-led interventions have also yielded improvements in ID consultations, targeted antimicrobial therapies, and compliance with quality-of-care standards (Wenzler et al., 2017).

The implementation of prospective audit and feedback conducted by ID physicians and pharmacists has proven effective in enhancing antimicrobial use and outcomes. For instance, introducing this practice in two intensive care units significantly reduced overall antimicrobial use (Taggart et al., 2015) and, in a teaching hospital setting, showed trends toward shorter hospital stays, reduced broad-spectrum antimicrobial use, lower antimicrobial costs, and fewer adverse events (Morrill et al., 2016).

Pharmacists working on infection review teams play a crucial role in facilitating intravenous-to-oral transitions and identifying patients eligible for oral therapy or outpatient parenteral antimicrobial therapy (OPAT) upon discharge (Dryden et al., 2012). In cases where the infection is controlled, early discharge with suitable oral therapy or OPAT can be arranged under good clinical governance and AMS practices (Nathwani et al., 2016).

While hospitals often have resources to support optimized prescribing and antimicrobial monitoring, similar resources are less readily available in community settings, complicating the implementation of these strategies and necessitating additional support (Garau et al., 2014). Residents of long-term care facilities (LTCFs) are particularly vulnerable to healthcare-associated infections, with 50–80% of residents prescribed at least one antimicrobial course annually (Dyar et al., 2015). In three community LTCFs, weekly prospective audit and feedback strategies faced implementation challenges, including missed opportunities for intervention and low acceptance rates of recommendations, despite the involvement of an ID physician and pharmacist (Doernberg et al., 2015). This underscores the need for ongoing medical education on AMR and AMS for LTCF staff, paired with a prospective audit and feedback approach, to address inappropriate antimicrobial use (Dyar et al., 2015). A systematic review of five studies found that pharmacist-led interventions incorporating access to medical records, medication reviews, feedback to physicians, and computer alerts identifying potentially inappropriate medications improved prescribing practices in older adults receiving primary care (Riordan et al., 2016).

Infection Prevention

Pharmacists have a vital role in reducing the transmission of infections within healthcare systems, including among patients and healthcare workers. The American Society of Health-System Pharmacists (ASHP) has outlined methods pharmacists can use to achieve this (Billstein-Leber et al., 2018). Additionally, pharmacists should actively promote vaccines, which can reduce antibiotic usage both directly, by preventing primary infections, and indirectly, by mitigating bacterial superinfections.

Education, Training, and Public Engagement

Education and training are integral to AMS optimization, and pharmacists play a central role in educating healthcare professionals, patients, and the public about stewardship (Billstein-Leber et al., 2018; Gilchrist et al., 2015). As key healthcare educators, pharmacists often serve as the first point of contact for the public, making them a critical source of information on antimicrobial use and resistance. Public understanding of antimicrobial resistance is essential since most antimicrobials are prescribed in community settings, and prescriber behaviour may be influenced by patient expectations (Johnson et al., 2015; McNulty & Francis, 2010).

Pharmacists are also involved in public health education and awareness programs focused on AMR and infection control. However, these programs must be multifaceted, targeting both healthcare professionals and the public, to be effective in fostering the understanding that antimicrobials are finite resources to be reserved for severe infections (McNulty & Francis, 2010).

The Infectious Diseases Society of America, the Society for Healthcare Epidemiology of America, and the Centers for Disease Control and Prevention (CDC) recognize prospective audit with intervention and feedback (PAIF) as a core antimicrobial stewardship program (ASP) strategy (Barlam et al., 2016). PAIF aims to optimize antibiotic use while mitigating adverse effects such as drug toxicity, bacterial resistance, and Clostridium difficile infections in real-time. This approach

involves reviewing patients on antimicrobial therapy to evaluate the appropriateness of their treatment in terms of indication, drug choice, dosage, administration route, and duration. Symptoms and diagnostic evidence should align with the prescribed antimicrobial. Additionally, the chosen agent must effectively target the most likely pathogens and be dosed according to pharmacokinetic and pharmacodynamic principles. Importantly, shorter treatment durations, supported by multiple studies, have shown to be as effective as longer courses in many infections, underscoring the necessity of reviewing therapy duration (Spellberg, 2016).

After assessing a patient, any recommended adjustments to the antimicrobial regimen are communicated to the provider through notifications in the patient's medical record or via direct verbal communication. PAIF is typically conducted by clinical pharmacists, preferably those with formal training in infectious diseases (ID) or AMS. Depending on the resources available and the healthcare setting, PAIF may follow either a one-step or two-step method. In the one-step model, trained pharmacists independently perform audits and provide feedback, consulting an ID physician only for complex cases. In contrast, the two-step method requires pharmacists to review cases and present their recommendations to an ID physician for approval before discussing them with the treating provider (Chung et al., 2013).

Pharmacists use various strategies to select patients for PAIF. These include focusing on specific infections, such as respiratory or urinary tract infections, targeting patient locations where antimicrobial use is high (e.g., ICUs), or prioritizing specific antibiotics identified by consumption data, such as restricted, broad-spectrum, high-cost, or potentially toxic agents. Interventions may involve de-escalation or broadening of therapy, discontinuation, optimization of drug, dose, or duration, switching from intravenous to oral therapy, ordering ID consultations, therapeutic drug monitoring, laboratory testing, addressing drug-drug interactions, and reducing unnecessary duplicate antimicrobial coverage.

An advantage of PAIF is that it allows providers to maintain prescribing autonomy, as accepting recommendations is voluntary (Barlam et al., 2016). The feedback process also enables pharmacists to educate providers during interventions. Through PAIF, pharmacists can tailor therapy to individual patient needs and perform reviews at multiple points during a patient's antimicrobial treatment. However, PAIF can be time-intensive for pharmacists, requiring substantial effort for reviews, provider communication, and documentation, especially in large healthcare settings with limited resources or personnel dedicated to AMS. Despite these challenges, pharmacists play a vital role in PAIF by identifying areas for intervention, documenting their efforts, and analyzing data to maximize the positive impact on patient outcomes and antimicrobial use.

Another significant benefit of PAIF is its role in identifying patients who may benefit from ID consultations. Such consultations are associated with reduced mortality and hospital readmissions and are particularly valuable for patients with complex infections, multidrug-resistant pathogens, or multiple comorbidities. Pharmacists conducting PAIF can identify these patients and recommend ID involvement. A recent study in Veterans Affairs hospitals found that implementing

an ASP with PAIF increased the rate of ID consultations, including within 48 hours of hospital admission (Morrill et al., 2014).

Transitions of Care with Antimicrobials

While most AMS efforts have traditionally focused on antimicrobial use during hospitalization, many patients complete their antimicrobial courses after discharge (Avdic et al., 2012; Jenkins et al., 2011, 2013). However, studies show that approximately two-thirds of antimicrobials prescribed at discharge are inappropriate in terms of indication, duration, spectrum, dose, or frequency (Scarpato et al., 2017; Yogo et al., 2017).

One quasi-experimental retrospective cohort study evaluated the effects of institutional guidance for oral step-down antimicrobial selection and duration, combined with pharmacist audits of discharge prescriptions and real-time feedback to providers. The intervention reduced the prescription of broad-spectrum gram-negative antimicrobials (from 51% to 40%), including a significant reduction in fluoroquinolone use (from 38% to 25%). Although the total duration of therapy did not significantly decrease, the duration of antimicrobials prescribed at discharge was reduced. Overall antimicrobial appropriateness improved from 72% to 90%, with the most notable benefits observed in community-acquired pneumonia, urinary tract infections, and skin infections. These infections were identified as high-yield targets for AMS interventions (Scarpato et al., 2017).

The same study found that pharmacists reviewed 40% of 918 discharge antimicrobial prescriptions, contacting providers in 27% of cases and recommending therapy modifications in 86% of these instances, with a 67% acceptance rate. Common interventions included optimizing antibiotic selection, dosing, and treatment duration. Patient outcomes, including treatment failure and infection-related readmissions, showed no significant differences between pre- and post-intervention groups. However, there was a nonsignificant trend toward reduced Clostridium difficile infections (2% vs. 0%) and adverse events (7% vs. 3%) (Lim et al., 2014).

Incorporating AMS pharmacists during the transition from inpatient to outpatient care is crucial for limiting inappropriate antimicrobial use and minimizing adverse consequences for patients. Interventions at transitions of care should focus on reducing antimicrobial prescriptions lacking a clear indication, addressing inappropriate durations, and optimizing the spectrum of activity.

Long-Term Care and Outpatient Settings

The inappropriate use of antimicrobials is not confined to hospitals. According to the CDC, up to 70% of nursing home residents receive at least one antibiotic course annually, and as much as 75% of antimicrobials prescribed in long-term care settings are either unnecessary or incorrect (Lim et al., 2014; Nicolle et al., 2000). Similarly, antimicrobial use in outpatient settings contributes to adverse patient outcomes, increased resistance, higher healthcare costs, and elevated morbidity and mortality rates (Bourgeois et al., 2009; Owens Jr. et al., 2008; Shehab et al., 2008). Notably, many antimicrobials prescribed in outpatient settings are for conditions that typically do not require such treatments (Shapiro et al., 2014). Recognizing this, the 2014 White House Administration issued an Executive Order to Combat Antibiotic-

Resistant Bacteria, emphasizing the need for antimicrobial stewardship programs (ASPs) across long-term care and outpatient settings.

Currently, there is limited evidence to identify impactful and sustainable AMS interventions in these settings. Factors driving antibiotic misuse or overprescription in outpatient and long-term care settings are multifaceted, making interventions more challenging compared to hospitals, where providers, pharmacists, and patients are co-located. Despite these challenges, pharmacists play a crucial role in ASPs in outpatient and long-term care environments, with their expertise contributing significantly to achieving stewardship goals.

Pharmacists have established a presence in physician offices and long-term care facilities by offering medication management services. With additional AMS training, these pharmacists can act as ASP champions. Training opportunities are available through organizations such as the Society of Infectious Diseases Pharmacists and the Making a Difference in Infectious Diseases programs. In outpatient and long-term care settings, pharmacists contribute to AMS by educating healthcare professionals about appropriate antimicrobial use and resistance. This education occurs through multidisciplinary collaborations, local guideline development, academic detailing, continuing education for providers and nurses, and patient education initiatives. Pharmacists also assist in monitoring antimicrobial prescribing rates to identify opportunities for high-impact interventions and conduct reviews of antimicrobial regimens, addressing issues such as discontinuation, duration, de-escalation, and dose optimization.

In outpatient office-based settings, pharmacists support prescribers in determining the necessity of antimicrobial treatments and selecting appropriate agents. Point-of-care (POC) testing in community pharmacies and ambulatory settings is another opportunity to optimize AMS. Studies demonstrate the effectiveness of POC testing for influenza and group A streptococcal pharyngitis in community and ambulatory settings, showing no adverse outcomes while aiding appropriate antimicrobial decisions (Klepser et al., 2016; Thornley et al., 2016). Although the CDC has provided Core Elements of Outpatient Antibiotic Stewardship to guide AMS expansion in outpatient care, further research is needed to identify the most effective practices for implementation. Pharmacists play a pivotal role in these settings, but more evidence is required to delineate their contributions and overcome existing barriers.

Concordance with Regulatory Requirements

AMS, long regarded as best practice, has recently gained traction in terms of standardization. The Centers for Medicare and Medicaid Services proposed a 2016 rule mandating AMS in hospitals as a condition for participation, later extending this requirement to nursing facilities in 2017. Beginning January 1, 2017, The Joint Commission required AMS programs in all acute care hospitals, critical access hospitals, and nursing facilities. The regulatory framework includes seven Elements of Performance (EPs) for hospitals and eight for nursing homes. These elements encompass leadership support for AMS, staff education on AMS and resistance, establishing a multidisciplinary AMS team (including an ID-trained physician and

pharmacist), adherence to CDC Core Elements of AMS, development of institution-specific protocols for appropriate antibiotic use, monitoring and reporting AMS data, and implementing action plans to improve antimicrobial use based on identified gaps. Nursing facilities must also educate residents and their families on AMS and resistance.

Pharmacists are recognized as essential members of the AMS team (Barlam et al., 2016). According to the Society for Infectious Diseases Pharmacists, all pharmacists play a role in AMS, even without formal ID training (Heil et al., 2016). Their responsibilities include using institutional protocols to optimize antimicrobial use, such as transitioning patients from intravenous to oral antibiotics to facilitate discharge and de-escalating antimicrobial therapy. The American Society for Health-System Pharmacists provides additional guidance, emphasizing the leadership role of pharmacists in promoting interdisciplinary collaboration, participating in pharmacy and therapeutics committees, utilizing clinical decision-support systems, and educating healthcare professionals, patients, and families (Billstein-Leber et al., 2018). Given their integral involvement in interdisciplinary collaboration and daily patient care activities, pharmacists are well-positioned to ensure compliance with all EPs for AMS, thereby meeting accreditation requirements.

## 2. Conclusion

Antimicrobial resistance (AMR) is a critical global health challenge, and antimicrobial stewardship (AMS) programs are essential in combating this issue. Pharmacists, as integral members of AMS teams, play a pivotal role in optimizing antimicrobial use across various healthcare settings, including hospitals, long-term care facilities, and outpatient environments. Through strategies such as prospective audit with intervention and feedback, transitions of care management, infection prevention, and education, pharmacists contribute to improving patient outcomes and minimizing the emergence of resistance.

Pharmacists are uniquely positioned to lead AMS efforts due to their expertise in medication management and their capacity for interdisciplinary collaboration. However, barriers such as resource limitations, insufficient training opportunities, and the complexity of implementing AMS in non-hospital settings highlight the need for enhanced support and education. Regulatory requirements and evidence-based guidelines underscore the importance of AMS, with pharmacists playing a central role in ensuring compliance and driving sustainable interventions.

As healthcare systems continue to evolve, pharmacists' involvement in AMS will remain crucial in reducing inappropriate antimicrobial use, fostering responsible prescribing practices, and mitigating the global impact of AMR. Further research and resource investment are needed to expand the reach and effectiveness of AMS programs, particularly in outpatient and long-term care settings, ensuring these critical initiatives can achieve their full potential.

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