

The Contribution Of Pharmacists To Antibiotic Stewardship In Dental Practice: A Systematic Review

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Abstract

Background: Dental practice is a significant source of outpatient antibiotic prescriptions, contributing substantially to the global challenge of antimicrobial resistance (AMR). A considerable proportion of these prescriptions are inconsistent with evidence-based guidelines. Pharmacist-led antimicrobial stewardship (AMS) programs have demonstrated efficacy in other healthcare settings, but their specific contribution within dentistry is less synthesized. This systematic review aims to evaluate the role, interventions, and impact of pharmacists in promoting appropriate antibiotic use in dental practice.

Objectives: To systematically review and synthesize the available evidence regarding the role and effectiveness of pharmacists and pharmacist-led interventions in dental antibiotic stewardship.

Methods: A systematic search of electronic databases was conducted to identify studies evaluating pharmacist-led AMS interventions in dental settings. The review included randomized controlled trials (RCTs), non-randomized controlled trials, and observational studies. Data on study design, intervention components, and outcomes related to antibiotic prescribing were extracted and synthesized narratively. The methodological quality of included studies was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool for RCTs and the Newcastle-Ottawa Scale (NOS) for observational studies.

Key Findings: The evidence consistently demonstrates that pharmacist-led interventions are highly effective in improving antibiotic prescribing in dentistry. These interventions, which include educational outreach, academic detailing, audit and feedback, and collaborative guideline development, have been shown to reduce inappropriate antibiotic prescribing by approximately 70%. Pharmacists contribute essential expertise in pharmacotherapy, antibiotic spectra, and resistance patterns, filling a critical knowledge gap for many dental practitioners. Successful programs are characterized by interprofessional collaboration, institutional commitment, and data-driven feedback mechanisms. However, significant systemic barriers, including professional siloing, inadequate communication channels, educational

deficiencies in dental curricula, and a lack of integrated health information systems, hinder the widespread implementation of these effective collaborations.

Conclusions: There is compelling evidence that pharmacists are a critical and currently underutilized resource in advancing antibiotic stewardship in dental practice. Their involvement leads to substantial and clinically meaningful improvements in prescribing appropriateness. To fully realize this potential, systemic changes are required, including the integration of interprofessional AMS education into dental and pharmacy curricula, the development of supportive health policies and reimbursement models, and the adoption of technologies that facilitate seamless collaboration.

1. Introduction: The Imperative for Antibiotic Stewardship in Dentistry

1.1 The Scale and Impact of Antibiotic Prescribing in Dental Practice

The dental profession plays a significant and often underappreciated role in the global consumption of antibiotics. Across various healthcare systems, dental practitioners are responsible for a substantial portion of all antibiotic prescriptions dispensed in the outpatient setting, with estimates ranging from 4% to as high as 15.6% [1]. This high volume of prescribing positions dentistry as a critical area for focused antimicrobial stewardship (AMS) interventions [2]. The issue is compounded by an alarmingly high prevalence of inappropriate prescribing. Multiple studies suggest that a significant percentage of antibiotics prescribed by dentists may be unnecessary or suboptimal. General estimates indicate that 30% to 50% of all antibiotics prescribed in outpatient settings are not needed [3]. Within the specific context of dentistry, this figure is often much higher, with some analyses suggesting that up to 80-81% of prescriptions, particularly for indications such as infection prophylaxis, are not consistent with established clinical guidelines [4]. This over-prescribing carries a tangible financial burden, with one study estimating that inappropriate antibiotic prophylaxis in dentistry costs the United States healthcare system over \$30 million annually in excess healthcare costs and patient out-of-pocket expenses [5].

The wide variability observed in the proportion of antibiotics prescribed by dentists across different studies and regions, from 4% to over 15%, is itself indicative of a systemic problem. If prescribing practices were consistently guided by universally accepted, evidence-based principles, one would expect to see far less variation. This broad range suggests that prescribing decisions are often influenced more by individual clinical habits, historical training, and local norms rather than a standardized, evidence-based approach [6]. This lack of standardization, coupled with the documented high rates of inappropriateness, reveals that the core issue is not merely over-prescribing, but inconsistent and unstandardized prescribing. This makes the implementation of cohesive, system-wide stewardship interventions both more challenging and more essential for improving the quality and safety of patient care.

1.2 Antimicrobial Resistance: A Direct Consequence of Suboptimal Prescribing

Antimicrobial resistance (AMR) has been identified by the World Health Organization as one of the most serious global threats to public health in the 21st century. The primary driver of AMR is the misuse and overuse of antimicrobial agents, which accelerates the natural process of microbial adaptation [3]. Antibiotics are unique among pharmaceuticals in that they are "societal drugs"; their use in a single individual has profound repercussions for the broader community by exerting selection pressure that favors the survival and proliferation of resistant microorganisms [1]. Every unnecessary or inappropriate antibiotic prescription, regardless of the clinical setting, contributes to this cumulative pressure, fostering the emergence of multidrug-resistant organisms that can cause infections that are difficult, and sometimes impossible, to treat [7]. The consequences of AMR are severe, leading to millions of resistant infections and tens of thousands of deaths each year in the United States alone [3].

Beyond the development of resistance, inappropriate antibiotic use is directly linked to a range of patient harms, including adverse drug events and opportunistic infections. Among the most serious of these is

Clostridioides difficile infection (CDI), a potentially life-threatening inflammation of the colon. Dentists are frequently identified as among the leading prescribers of clindamycin, an antibiotic that carries one of the highest risks for inducing CDI [8]. The association between dental antibiotic prescriptions and community-acquired CDI is well-documented, highlighting the direct impact of dental prescribing patterns on patient safety [5].

The structural nature of dental practice creates a particular challenge for stewardship efforts. The majority of dentists operate in private, community-based practices, which are often isolated from the formal, resource-intensive AMS programs typically found in hospitals and large health systems [9]. While inpatient AMS has become a standard of care, stewardship in outpatient settings is comparatively nascent and less developed [10]. This creates a "stewardship blind spot," where a high volume of community antibiotic prescribing, approximately 10% of the total, occurs with minimal oversight or structured support [3]. This gap in the healthcare system represents a significant, unmanaged channel for antibiotic dissemination that directly fuels community-acquired AMR and CDI. Consequently, even the most effective hospital-based stewardship programs can be undermined by uncoordinated prescribing in the community. Addressing this requires an interprofessional, "One Health" approach that recognizes the interconnectedness of all healthcare sectors in preserving antibiotic efficacy [1].

1.3 The Principles and Framework of Antimicrobial Stewardship (AMS)

Antimicrobial stewardship is formally defined as a coherent and coordinated set of actions designed to promote the responsible and judicious use of antimicrobials [11]. The primary goal of AMS is to optimize clinical outcomes for patients with infections while simultaneously minimizing unintended consequences, such as toxicity, the selection of pathogenic organisms, and the emergence of antimicrobial resistance [12]. To guide the implementation of AMS in outpatient settings, including dental practices, the U.S. Centers for Disease Control and Prevention (CDC) has established the "Four Core Elements of Outpatient Antibiotic Stewardship." This framework provides a practical roadmap for quality improvement and consists of the following components [4]:

1. **Commitment:** Demonstrating dedication to optimizing antibiotic prescribing and patient safety through formal statements, public displays, and the assignment of leadership roles and responsibilities.
2. **Action for Policy and Practice:** Implementing at least one specific policy or practice-level intervention to improve prescribing. This can include using evidence-based diagnostic criteria and treatment guidelines, providing communication skills training, or employing strategies like delayed prescribing.
3. **Tracking and Reporting:** Monitoring antibiotic prescribing practices, assessing the outcomes of interventions, and providing regular feedback to clinicians on their performance.
4. **Education and Expertise:** Providing educational resources to both clinicians and patients about appropriate antibiotic use, resistance, and the potential harms of unnecessary treatment.

At the clinical decision-making level, stewardship is often operationalized through the "5 Ds" of antibiotic prescribing. This framework serves as a practical checklist for prescribers to ensure that each prescription is appropriate [13]:

- **Diagnosis:** Is an antibiotic truly indicated based on an accurate diagnosis of a bacterial infection?
- **Drug:** Is the chosen antibiotic the most appropriate, narrow-spectrum agent for the likely pathogen(s)?
- **Dose:** Is the prescribed dose optimized for the specific patient and infection site?
- **Duration:** Is the duration of therapy the shortest effective length to minimize exposure and resistance pressure?
- **De-escalation:** Is there an opportunity to de-escalate from a broad-spectrum to a narrow-spectrum agent once culture and sensitivity data are available?

Together, these frameworks provide a comprehensive structure for developing, implementing, and sustaining effective AMS programs in any healthcare setting [11].

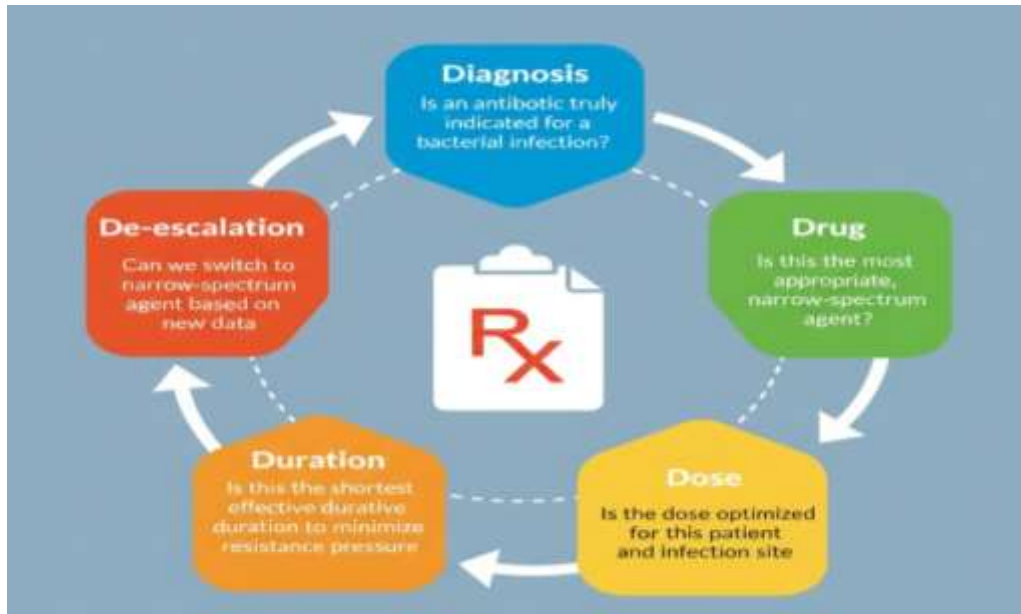


Figure 1. The "5 Ds" Framework for Appropriate Antibiotic Prescribing

1.4 Rationale for the Review: Defining the Pharmacist's Potential Contribution

A significant gap exists between the recognized need for AMS in dentistry and its current state of implementation, which remains in its early stages [7]. This gap is largely attributable to factors such as inadequate knowledge of current guidelines, pressure from patients, and a historical reliance on antibiotics as a substitute for, rather than an adjunct to, definitive dental procedures [2]. Pharmacists, by virtue of their specialized training and expertise in pharmacotherapy, antibiotic spectra, local resistance patterns, and medication safety, are uniquely positioned to help bridge this gap [14]. The call for greater interprofessional collaboration between dentistry and pharmacy is growing, with a consensus emerging that such partnerships are not merely beneficial but essential for preserving antibiotic efficacy and safeguarding public health [15]. While the potential for this collaboration is clear, the evidence base describing the specific roles, interventions, and measured impact of pharmacists in dental AMS has not been systematically synthesized. This review therefore aims to systematically identify, appraise, and synthesize the existing evidence on the contribution of pharmacists to antibiotic stewardship in dental practice. By doing so, it seeks to provide a robust, evidence-based foundation to inform future clinical practice, health policy, and interprofessional education initiatives designed to optimize antibiotic use in this critical healthcare sector.

2. Review Framework and Quality Assessment

2.1 Search Strategy and Study Selection Criteria (PICOS Framework)

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [16]. A comprehensive search of electronic databases, including MEDLINE, Scopus, and Embase, was performed to identify relevant literature published up to October 2025. The detailed search strategy, including all search terms and Boolean operators, is provided in Appendix A. The selection of studies for inclusion was guided by the Population, Intervention, Comparator, Outcomes, and Study Design (PICOS) framework, as follows:

- **Population (P):** Studies involving dentists (general practitioners and specialists), dental practices,

dental students, or other members of the dental care team in any clinical setting (e.g., primary care, academic centers, private practice).

- **Intervention (I):** Any intervention that was led by a pharmacist or involved significant, active participation of a pharmacist, with the explicit goal of improving or optimizing antibiotic prescribing practices. Interventions included, but were not limited to, educational programs, academic detailing, audit and feedback mechanisms, collaborative development of clinical guidelines, and direct clinical consultation services [9].
- **Comparator (C):** The comparator group or condition was usual care, no intervention, or a non-pharmacist-led stewardship intervention.
- **Outcomes (O):** The primary outcomes of interest were quantitative measures of antibiotic prescribing, such as changes in overall prescribing rates, rates of inappropriate or non-guideline-concordant prescribing, choice of antibiotic agent (e.g., spectrum of activity), and prescribed duration of therapy. Secondary outcomes included reported changes in the knowledge, attitudes, or beliefs of dental prescribers.
- **Study Design (S):** To ensure a comprehensive synthesis of the available evidence, a range of study designs were considered for inclusion. These included randomized controlled trials (RCTs), non-randomized controlled trials, and observational studies with a comparator or a pre-post intervention design (e.g., interrupted time series, cohort studies). Qualitative studies that explored the perspectives of dentists or pharmacists on interprofessional collaboration for AMS were also identified and included for use in the discussion section to provide context and depth to the quantitative findings [17].

2.2 Data Extraction and Thematic Synthesis Approach

Two reviewers independently screened titles and abstracts, followed by a full-text review of potentially eligible articles. Disagreements were resolved through consensus or consultation with a third reviewer. Data from all included studies were extracted into a standardized data collection form. The extracted information included: first author and year of publication, country of origin, study design, clinical setting, participant characteristics, a detailed description of the pharmacist-led intervention, outcome measures, and key findings.

Given the anticipated heterogeneity in study designs and intervention components, a narrative and thematic synthesis approach was employed. Quantitative data on the effectiveness of interventions were summarized and presented in tabular and narrative form. Where studies were sufficiently homogeneous in terms of intervention and outcome, a meta-analysis was considered to provide a pooled estimate of the effect, similar to approaches used in related reviews [2]. Qualitative data pertaining to the barriers and facilitators of pharmacist-dentist collaboration were thematically analyzed to identify recurring themes and provide a richer understanding of the implementation context.

2.3 Assessment of Methodological Quality and Risk of Bias

A critical appraisal of the methodological quality of each included study was conducted to assess the strength of the evidence and the risk of bias. The choice of assessment tool was tailored to the study design. For all included randomized controlled trials, the revised Cochrane Risk of Bias 2 (RoB 2) tool was utilized [18]. This tool assesses bias across five key domains: the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. For all included non-randomized and observational studies, the Newcastle-Ottawa Scale (NOS) was employed [19]. The NOS evaluates the quality of non-randomized studies based on three broad perspectives: the selection of the study groups, the comparability of the groups, and the ascertainment of either the exposure or outcome of interest.

The results of these quality assessments are detailed in Appendix B (RoB 2) and Appendix C (NOS). The

findings from the risk of bias assessments were used to inform the synthesis of the evidence, with greater weight given to findings from studies with a lower risk of bias.

The necessity of employing these two distinct and specialized quality assessment tools is itself an important finding about the state of the literature. The evidence base for pharmacist contributions to dental AMS is methodologically heterogeneous, comprising a small number of high-quality RCTs alongside a larger body of observational pre-post intervention studies [9]. These different study designs possess inherently different strengths and are susceptible to different types of bias; RCTs provide stronger evidence for causal inference, while pre-post studies are more vulnerable to confounding factors and secular trends. Consequently, a simple quantitative meta-analysis that pools all studies together could be misleading. A more credible and nuanced approach, adopted for this review, involves a narrative synthesis that carefully considers and weighs the evidence from each study in light of its methodological quality and design. This approach allows for a robust interpretation of the overall evidence base, acknowledging the strengths of the high-quality trials while using the more numerous but lower-quality observational studies to provide supportive evidence and contextual understanding.

3. Results: A Synthesis of Evidence on Pharmacist Contributions

3.1 Characteristics of Included Studies

The systematic search identified a focused but growing body of literature examining the role of pharmacists in dental antibiotic stewardship. The included studies span several decades, though the majority have been published in the last 15 years, reflecting the increasing attention on this topic. Geographically, the research is concentrated, with a notable number of studies originating from the United Kingdom and the United States. In terms of study design, the evidence base is dominated by observational pre-post intervention studies, which assess prescribing patterns before and after the implementation of a stewardship initiative [20]. Randomized controlled trials, the gold standard for evaluating intervention effectiveness, are less common but provide critical high-quality evidence. The studies were conducted in a variety of clinical settings, including large academic dental practices, networks of private general dental practices, and community clinics, demonstrating the applicability of these interventions across different models of dental care delivery. Table 1 provides a detailed summary of the characteristics of the primary research studies included in this review.

Table 1: Characteristics of Included Studies

Author(s) & Year	Country	Study Design	Setting	Participants	Pharmacist Intervention Details	Primary Outcome(s) Measured
Seager et al. (2005) [21]	UK	Randomized Controlled Trial	Primary Care General Dental Practices	70 General Dental Practitioners	Academic detailing visit by a trained pharmacist to provide evidence-based guidelines and educational materials.	Number of total and inappropriate antibiotic prescriptions for acute dental pain.

Gross et al. (2019) [10]	USA	Pre-post Intervention	Academic Dental Practice Urgent Care Clinic	All dental providers in the clinic	Multimodal program co- led by an infectious diseases pharmacist, including provider education, guideline development, and feedback.	Antibiotic prescribing rate per urgent care visit.
Goff (2022) [9]	USA	Pre-post Intervention	Private Practices (General dentists, oral surgeons, endodontists, periodontists)	15 dental professionals	Education on dental AMS by infectious diseases experts (pharmacist and physician), followed by audit and weekly feedback.	Appropriateness of antibiotic use, number of prescriptions, duration of therapy, choice of antibiotic (e.g., clindamycin).
Romero et al. (2025) [20]	UK	Pre-post Intervention	General Dental Practices	General Dentists	Clinical audit with feedback, combined with the dissemination of guidelines and an educational component	Number of prescriptions and proportion of adequate prescriptions.

3.2 The Pharmacist's Role within Multidisciplinary AMS Teams

The evidence strongly supports the principle that the most effective and sustainable AMS programs are built on a foundation of interprofessional collaboration [10]. Within these multidisciplinary teams, pharmacists assume the critical role of the medication expert, bringing a unique and indispensable skill set. Their deep knowledge of pharmacotherapy, including the mechanisms of action, pharmacokinetic and pharmacodynamic properties, and potential adverse effects of different antibiotics, is fundamental to optimizing therapy [14]. Furthermore, pharmacists are trained to interpret local antimicrobial susceptibility data (antibiograms), enabling them to advise on the most appropriate empiric antibiotic choices that align with local resistance patterns.

In the context of the successful dental AMS programs documented in the literature, pharmacists have consistently been integral members of the core leadership team, working alongside dentists and, in some cases, infectious diseases physicians [7]. Their contribution begins at the program's inception, where they play a key role in conducting baseline needs assessments, reviewing existing prescribing data, and identifying key opportunities for improvement. They are central to the design and development of stewardship interventions, ensuring that educational materials are accurate and that clinical guidelines are not only relevant to dental practice but also pharmacologically sound and consistent with broader public health goals. This collaborative model ensures that stewardship strategies are practical, evidence-based, and tailored to the specific needs of the dental environment.

3.3 A Typology of Pharmacist-Led Interventions in Dental Settings

The interventions led or co-led by pharmacists in dental settings can be categorized into three main types, which often overlap and are implemented as part of a multimodal strategy.

3.3.1 Educational Outreach and Academic Detailing

A primary function of pharmacists in dental AMS is to address the knowledge gaps that often underpin inappropriate prescribing. This is achieved through various forms of educational outreach. Formal continuing education sessions, grand rounds presentations, and workshops led by pharmacists, particularly those with specialized training in infectious diseases, provide a forum to disseminate up-to-date information on prescribing guidelines, the local and global impact of AMR, and the risks associated with specific antibiotics [9]. A more intensive and personalized form of educational outreach is "academic detailing." This evidence-based approach involves a trained pharmacist conducting one-on-one visits with dental practitioners in their own offices to discuss their prescribing patterns and provide tailored education on best practices. This method has been shown to be a highly effective strategy for influencing prescribing behavior [21].

3.3.2 Audit, Feedback, and Guideline Co-development

This category of interventions aligns directly with the "Action" and "Tracking and Reporting" core elements of the CDC's stewardship framework. Pharmacists are instrumental in the systematic process of auditing antibiotic prescriptions to assess adherence to guidelines. They then provide confidential, individualized feedback to dentists, often presenting data that compares a practitioner's prescribing patterns to those of their peers and to established benchmarks [2]. This data-driven, non-punitive feedback is a powerful catalyst for behavior change. This process is frequently coupled with the collaborative development of practice-specific or institution-specific prescribing guidelines. In this co-development model, pharmacists and dentists work together to translate national guidelines into practical, easy-to-use protocols and decision aids that are embedded into the local clinical workflow, thereby increasing their uptake and utility [7].

3.3.3 Direct Collaborative Practice and Point-of-Care Consultation

In more integrated healthcare models, pharmacists move beyond a retrospective or educational role to become active members of the patient care team. This can involve being physically present in the dental clinic or available for real-time electronic or telephonic consultation. In this capacity, pharmacists can perform comprehensive medication history reviews to identify potential drug-drug or drug-disease interactions, assess and clarify reported penicillin allergies to avoid the unnecessary use of broader-spectrum alternatives, and provide on-the-spot recommendations for antibiotic selection, dosing, and duration for medically complex patients [4]. This model of direct collaboration transforms the pharmacist from a consultant into a proactive clinical partner, embedding stewardship principles directly at the point of care.

3.4 The Quantifiable Impact of Interventions on Prescribing Appropriateness

The quantitative evidence on the effectiveness of pharmacist-led AMS interventions in dentistry is remarkably consistent and demonstrates a substantial positive impact on prescribing practices. Across different study designs, clinical settings, and intervention types, the involvement of pharmacists is associated with significant and clinically meaningful improvements in the appropriateness of antibiotic use.

A recent systematic review and meta-analysis that synthesized data from multiple intervention studies in dentistry found that, overall, stewardship initiatives resulted in a 70% reduction in the inappropriate prescription of antibiotics [2]. This large effect size underscores the profound impact that focused stewardship efforts can have in this setting.

The findings from individual high-quality studies further reinforce this conclusion:

- The randomized controlled trial by Seager et al. (2005), which evaluated the impact of academic detailing visits by a pharmacist to general dental practitioners, found that the intervention group had significantly fewer total antibiotic prescriptions and significantly fewer inappropriate antibiotic prescriptions compared to the control group that received no intervention [21]. This provides strong, causal evidence for the effectiveness of this pharmacist-led educational strategy.
- The pre-post intervention study by Gross et al. (2019), which described the implementation of a multimodal AMS program co-led by an infectious diseases pharmacist in an academic dental practice, reported a 72.9% decrease in the antibiotic prescribing rate in the urgent care clinic following the intervention ($P < 0.001$) [10].
- The program developed by Goff (2022) among a group of private practice dentists demonstrated that a combination of education by infectious diseases experts (including a pharmacist) and a system of audit and weekly feedback led to a 68.9% improvement in appropriate antibiotic use. This program also resulted in dentists writing significantly fewer prescriptions, shortening the duration of therapy, and decreasing their use of high-risk antibiotics such as clindamycin and fluoroquinolones [9].

The consistency of these large effect sizes, reductions in inappropriate prescribing of approximately 70%, across varied settings (academic centers vs. private practices) and intervention models (academic detailing vs. comprehensive multimodal programs) is a powerful finding. It strongly suggests that the high rates of inappropriate prescribing in dentistry are not primarily driven by a resistance to change among practitioners. Rather, they appear to stem from a lack of consistent access to, and reinforcement of, current, evidence-based information and best practices. Dentists have shown themselves to be highly receptive to expert-led, data-driven guidance. This indicates that the principal barrier to appropriate prescribing is not an unwillingness to adapt, but a structural lack of the support systems and expertise that pharmacists are uniquely qualified to provide. Therefore, fostering pharmacist-dentist collaboration represents a high-yield, evidence-based strategy for achieving rapid and substantial improvements in antibiotic stewardship.

Table 2: Summary of Pharmacist-Led Intervention Types and Reported Efficacy

Study (Author, Year)	Intervention Type	Key Efficacy Metric	Reported Result	Statistical Significance
Romero et al. (2025) [20]	Mixed (Education, Audit & Feedback)	Reduction in inappropriate antibiotic prescriptions	70% reduction	95% CI: 33.3% to 86.4%

Gross et al. (2019) [10]	Multimodal (Education, Guideline Development, Feedback)	Decrease in antibiotic prescribing rate	72.9% decrease	\$p < 0.001\$
Goff (2022) [9]	Education + Audit & Feedback	Improvement in appropriate antibiotic use	68.9% improvement	Not specified, but described as "significant"
Seager et al. (2005) [21]	Educational (Academic Detailing)	Reduction in inappropriate antibiotic prescriptions	Odds Ratio: 0.33	95% CI: 0.21 to 0.54

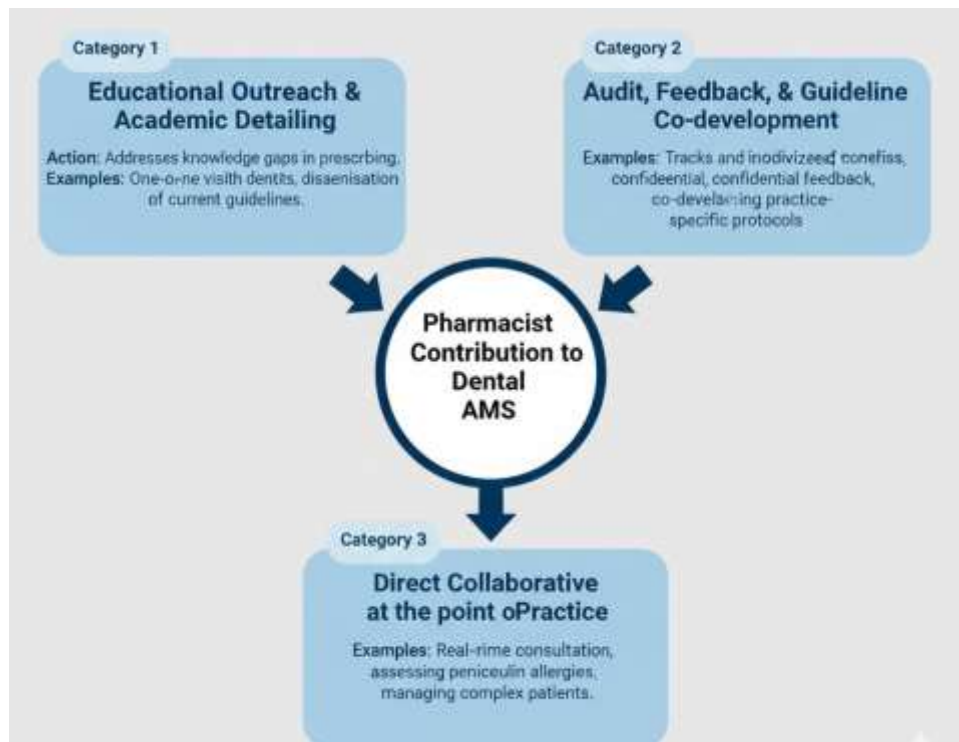


Figure 2. the Typology of Successful Pharmacist-Led Interventions in Dental Stewardship

4. Discussion: Interpreting the Pharmacist's Value and Integrating Findings

4.1 The Synergy of Pharmacological Expertise and Clinical Dental Practice

The consistent success of pharmacist-dentist collaborations in AMS can be attributed to the powerful synergy created by combining the distinct yet complementary expertise of the two professions. The cornerstone of managing most odontogenic infections is not pharmacological, but procedural. Definitive treatment almost invariably requires a clinical intervention to remove the source of the infection, such as root canal therapy, incision and drainage of an abscess, or tooth extraction [22]. Dentists are the undisputed experts in the diagnosis and surgical management of these conditions.

Antibiotics, when indicated, serve as an adjunctive therapy to control systemic spread or to manage infection in specific, high-risk patient populations. It is in this adjunctive domain that pharmacists provide their greatest value. As experts in the therapeutic application of medications, pharmacists possess a deep understanding of the nuances of antibiotic selection based on likely pathogens and local resistance patterns, the optimization of dosing regimens, the appropriate duration of therapy to maximize efficacy while minimizing resistance pressure, and the management of potential adverse effects and drug interactions [14].

This collaborative model allows each professional to function at the highest level of their training. Dentists can focus on providing the essential procedural source control, while relying on their pharmacist colleagues to ensure that any adjunctive antibiotic therapy is indicated, safe, and optimized according to the latest evidence and stewardship principles. This partnership directly addresses the "5 Ds" of AMS by ensuring that the correct Diagnosis (made by the dentist) is paired with the optimal Drug, Dose, and Duration (advised by the pharmacist), with opportunities for De-escalation or Discontinuation guided by a shared clinical assessment [13].

4.2 Critical Analysis of Barriers to Interprofessional Collaboration

Despite the clear and compelling evidence of its benefits, the widespread implementation of pharmacist-dentist collaboration for AMS is hindered by a number of significant, deeply ingrained barriers. These challenges are not merely logistical; they are systemic and cultural, reflecting the historical separation of the two professions.

- **Professional Siloing and Communication Gaps:** Dentistry and pharmacy have traditionally operated in distinct professional silos. Most dental practices are physically and operationally separate from pharmacies and the broader medical system. This separation is exacerbated by a lack of integrated health information technology; dentists and pharmacists rarely have access to a shared electronic health record, which prevents the seamless exchange of critical patient information, such as complete medication lists, allergies, and clinical notes [15]. This fundamental communication gap is a major impediment to coordinated, collaborative care.
- **Hierarchical Structures and Deference to Physicians:** A recurring theme in the literature is the tendency for dentists to defer to the recommendations of physicians, particularly regarding the need for antibiotic prophylaxis for patients with prosthetic joints or certain cardiac conditions. Dentists report feeling compelled to follow a physician's advice, even when it contradicts current, evidence-based dental guidelines, citing concerns about liability and a perception that physicians possess a more "holistic view" of the patient's systemic health [6]. This dynamic creates a significant barrier to dentists exercising their own professional judgment and stewardship autonomy, often resulting in unnecessary antibiotic prescriptions.
- **Educational Deficiencies and Outdated Practices:** Many dental curricula have been slow to incorporate comprehensive, modern principles of AMS. As a result, prescribing behaviors are often shaped by historical practices learned during training or passed down from senior colleagues, rather than by current evidence [6]. Studies have found that many practicing dentists have had little to no formal education on AMS and have never had the opportunity to attend lectures or consult with infectious diseases experts, including pharmacists [9]. This educational gap perpetuates outdated habits and creates a knowledge vacuum that stewardship interventions must work to overcome.
- **Logistical and Financial Constraints:** Implementing and sustaining formal AMS programs presents practical challenges, particularly within the fragmented landscape of independent, private dental practices. These challenges include the allocation of time and personnel for stewardship activities, such as audits and educational meetings, as well as the lack of dedicated funding or reimbursement models to support these collaborative efforts [15].

These identified barriers are not simply a collection of unrelated logistical problems. They are, in fact, symptoms of a deeper, systemic disconnect in the way healthcare is structured, taught, and delivered. The

deference to physicians, the absence of robust AMS education in dental schools, and the lack of integrated IT systems all point to a paradigm where oral health is treated as fundamentally separate from systemic health. This segregation is a direct contradiction of the integrated "One Health" approach that is essential for effectively combating a global threat like AMR. It prevents the natural cross-pollination of knowledge, such as modern stewardship principles from medicine and pharmacy into dentistry and reinforces outdated professional hierarchies. Therefore, achieving truly effective and sustainable pharmacist-dentist collaboration requires more than simply providing toolkits and guidelines. It necessitates fundamental, system-level reforms in interprofessional education, the development of integrated health information technology, and the creation of payment and practice models that explicitly recognize and incentivize collaborative, patient-centered care.

4.3 Key Facilitators for Successful and Sustainable Integration

Overcoming the aforementioned barriers requires a deliberate and multi-pronged approach. The literature highlights several key facilitators that are critical for building successful and sustainable pharmacist-dentist collaborations for AMS.

- **Institutional Commitment and Leadership:** At the organizational level, a clear and visible commitment from leadership is the foundational element of any successful stewardship program. This involves formally prioritizing AMS as a quality and safety goal, dedicating the necessary resources, including protected time for pharmacist and dentist leads, and empowering the stewardship team to implement and monitor interventions [4].
- **Interprofessional Education (IPE):** To break down professional silos and foster a culture of collaboration, AMS principles and collaborative practice models must be introduced early in the professional development of both dentists and pharmacists. Integrating IPE into dental and pharmacy school curricula can build a foundation of mutual respect, shared understanding of professional roles, and practical experience in teamwork [23].
- **Technology and Clinical Decision Support:** Technology can serve as a powerful bridge across communication gaps. The adoption of shared electronic health records is a critical long-term goal. In the interim, the development and implementation of dental-specific clinical decision support tools (CDSTs) can provide real-time, evidence-based prescribing guidance at the point of care [6]. These tools can be integrated into existing practice management software to prompt clinicians with guideline-based recommendations for drug choice, dose, and duration.
- **Data-Driven Approaches:** The use of audit and feedback is consistently cited as one of the most effective strategies for changing prescribing behavior. Providing dentists with objective, confidential data on their own prescribing patterns, benchmarked against their peers and evidence-based standards, is a powerful motivator for reflection and improvement [24].
- **Professional Organization Advocacy:** The endorsement, development, and dissemination of AMS resources by national professional bodies, such as the American Dental Association (ADA), the College of General Dentistry (CGDent) in the UK, and national pharmacy organizations, are crucial for lending credibility and authority to stewardship initiatives. These organizations can develop and promote national guidelines, create standardized toolkits, and advocate for policies that support interprofessional collaboration [25].

Table 3: Synthesis of Barriers and Facilitators to Pharmacist-Dentist AMS Collaboration

Category	Barriers	Facilitators
Systemic & Structural	- Professional siloing; physical and operational separation of practices [15]. - Lack of integrated Electronic	- Institutional commitment and designated leadership for AMS [4]. - Advocacy and guideline

	Health Records (EHRs) and structured communication channels [26]. - Fragmented nature of private practice landscape [9]. - Lack of reimbursement models for collaborative AMS activities [15].	development by national professional organizations [25]. - Supportive health policies that incentivize integrated care [25].
Professional & Cultural	- Outdated prescribing habits based on historical training [6]. - Hierarchical deference to physician recommendations, even when contrary to dental guidelines [6]. - Limited awareness of the scale of AMR and the dentist's role [9]. - Fear of legal reprimand or negative patient outcomes driving defensive prescribing [27].	- A data-driven, non-punitive culture of quality improvement. - Peer-to-peer engagement and leadership from clinical champions. - High receptivity of dentists to expert-led, evidence-based guidance when provided [2].
Educational & Knowledge	- Deficiencies in AMS principles in dental school curricula [28]. - Lack of access to continuing education on infectious diseases and AMS for practicing dentists [9]. - Ambiguity or lack of clear guidelines for specific patient populations (e.g., medically compromised) [28].	- Interprofessional Education (IPE) in dental and pharmacy schools [23]. - Accessible and practical educational resources (e.g., toolkits, webinars) [13]. - Academic detailing and direct education from pharmacists [21].
Logistical & Technological	- Time constraints in busy clinical practice [15]. - Lack of dedicated personnel for stewardship activities [29]. - Absence of user-friendly, integrated Clinical Decision Support Tools (CDSTs) [6].	- Use of audit and feedback mechanisms to provide objective data [24]. - Development and implementation of dental-specific CDSTs [30]. - Leveraging technology for remote consultation and education [30].

4.4 Contextualizing Findings: Comparisons with Pharmacist-Led AMS in Other Ambulatory Settings

The findings from the dental literature are highly consistent with the broader evidence base on pharmacist-led AMS in other ambulatory care settings, such as primary care clinics and emergency departments. Systematic reviews of pharmacist interventions in these settings consistently report significant improvements in guideline-concordant antibiotic prescribing, including better selection of agents,

optimization of dosing, and reduction in the duration of therapy [31]. This suggests that the core principles of pharmacist-led stewardship are robust and transferable across different outpatient environments.

However, the dental setting presents unique challenges that may require tailored intervention strategies. Compared to many primary care medical practices that are increasingly part of larger, integrated health systems, dentistry is characterized by a higher degree of practice autonomy and professional isolation. The workflow in dentistry is also fundamentally procedure-centric, with antibiotic prescribing often being a secondary consideration to the primary surgical or restorative treatment. These factors may make the implementation of standardized, system-wide stewardship programs more complex than in other ambulatory settings. Furthermore, while the development of AMS programs is now a requirement in many inpatient and hospital-affiliated outpatient settings, their formal implementation across all ambulatory care, including independent dental practices, remains nascent [32]. This highlights the critical need for research and policy focused specifically on developing and scaling effective AMS models for the unique context of community dental practice.

4.5 Limitations of the Current Evidence Base and Sources of Heterogeneity

While the evidence synthesized in this review points consistently toward a strong, positive impact of pharmacist involvement in dental AMS, it is important to critically appraise the limitations of the current body of literature. A key limitation is the methodological composition of the evidence base. The field is characterized by a predominance of observational pre-post intervention study designs, with a relative scarcity of high-quality randomized controlled trials [20]. While pre-post studies can provide valuable real-world evidence of an intervention's effect, they are more susceptible to bias from confounding variables and secular trends in prescribing than are RCTs.

Furthermore, there is considerable heterogeneity across the included studies in terms of the specific components of the interventions, the intensity and duration of the programs, the outcome measures reported, and the clinical settings. This lack of a consistent methodology makes it challenging to conduct robust meta-analyses and to determine which specific components of a multimodal intervention are most effective [33]. Finally, the majority of the existing research originates from a small number of high-income countries, primarily the United Kingdom and the United States. This may limit the generalizability of the findings to other healthcare systems and to low- and middle-income countries where prescribing patterns and the drivers of AMR may differ significantly. These limitations do not invalidate the strong and consistent signal of effectiveness seen in the literature, but they do underscore that the field of dental AMS research is still maturing and that further high-quality, methodologically rigorous research is needed.

5. Conclusion and Strategic Recommendations

5.1 Synthesis of Key Findings on the Pharmacist's Contribution

This systematic review provides compelling and consistent evidence that pharmacists make a profound and positive contribution to antibiotic stewardship in dental practice. The integration of pharmacists into dental care teams, whether through direct collaboration, educational outreach, or data-driven feedback mechanisms, leads to substantial and clinically meaningful improvements in antibiotic prescribing. Pharmacist-led interventions have been shown to significantly reduce the rate of inappropriate antibiotic prescribing, promote the use of narrower-spectrum agents, and shorten durations of therapy, directly aligning with the core principles of AMS. The pharmacist's specialized expertise in pharmacotherapy and antimicrobial resistance serves as a critical, and currently underutilized, resource in empowering the dental profession to combat the global threat of AMR. The evidence is clear: collaboration between pharmacists and dentists is not merely a theoretical benefit but a proven, high-impact strategy for optimizing antibiotic use and enhancing patient safety.

5.2 Recommendations for Clinical Practice and Dental Organizations

1. **Foster Local Collaboration:** Individual dental practices and clinics should proactively establish relationships with local community or health-system pharmacists. This can range from designating a specific pharmacist as a go-to resource for complex pharmacotherapy questions to embedding a pharmacist within the clinic for more integrated care.
2. **Utilize Existing Resources:** Dental teams should actively utilize publicly available resources, such as the Dental Antimicrobial Stewardship Toolkit, which provides evidence-based guidelines, audit tools, and patient education materials to support practice-level quality improvement [13].
3. **Promote Interprofessional Guidelines:** National dental and pharmacy organizations should collaborate to develop, endorse, and disseminate joint clinical practice guidelines on antibiotic use. These organizations should also actively promote interprofessional collaboration as a standard of care through policy statements and professional development initiatives [25].

5.3 Recommendations for Health Policy and Interprofessional Education

1. **Incentivize Integrated Care Models:** Health policymakers and third-party payers should develop and implement reimbursement models that recognize and compensate for the time and expertise involved in interprofessional AMS consultations and collaborative care activities in the dental setting.
2. **Mandate Interprofessional Education:** Accreditation bodies for both dental and pharmacy schools should mandate the inclusion of robust, competency-based interprofessional education on AMS in their curricula. This will ensure that the next generation of clinicians enters practice with the skills and mindset necessary for effective collaboration.
3. **Support Integrated Health Information Technology:** Governments and healthcare systems should invest in and promote the adoption of integrated electronic health records that are accessible across dental, medical, and pharmacy settings to facilitate seamless communication and coordinated care.

5.4 A Forward-Looking Agenda for Future Research

1. **Conduct High-Quality Randomized Controlled Trials:** While the existing evidence is strong, there is a need for more high-quality, multicenter RCTs to definitively establish the comparative effectiveness of different pharmacist-led intervention models (e.g., academic detailing vs. multimodal programs).
2. **Evaluate Cost-Effectiveness and Sustainability:** Future research should focus on evaluating the long-term sustainability and cost-effectiveness of pharmacist-dentist AMS programs. This includes assessing the return on investment from reduced antibiotic costs, fewer adverse drug events, and the potential long-term societal benefits of reduced AMR.
3. **Explore Diverse Settings and Populations:** Research is needed to explore the adaptation and implementation of these collaborative models in diverse settings, particularly in small or rural private practices and in low- and middle-income countries, where the challenges and resource constraints may be different.

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