

Antibiotic Stewardship in Dentistry: Current Practices, Challenges, and Future Directions

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Abstract

Antimicrobial resistance is a growing global public health threat driven largely by the inappropriate and excessive use of antibiotics across healthcare settings, including dentistry. Dentists contribute significantly to outpatient antibiotic prescribing, yet a substantial proportion of these prescriptions are unnecessary or inconsistent with evidence-based guidelines. This review examines current practices in antibiotic use within dentistry, highlighting appropriate clinical indications, common patterns of misuse, and their implications for patient outcomes and resistance development.

Keywords: Antibiotic stewardship, Antibiotic prescribing, Antimicrobial resistance, Dental infections, Dentistry.

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1. Introduction

Antibiotic stewardship refers to coordinated efforts to optimize the use of antimicrobial agents to improve patient outcomes, minimize unnecessary antibiotic exposure, and reduce the emergence of antimicrobial resistance (AMR). Effective stewardship encompasses appropriate selection, dosing, route, and duration of antibiotics based on evidence-based clinical criteria and guidelines [1,2]. Dentistry plays a significant role in antibiotic prescribing within healthcare. Dentists commonly prescribe antibiotics both to manage bacterial infections in the oral cavity and as a preventive measure before invasive dental procedures for patients at increased risk of complications. In 2013, general dentists were responsible for nearly 10% of all outpatient antibiotic prescriptions in the United

States, ranking fourth among prescribers after family physicians (24%), paediatricians (12%), and internists (12%). Despite this significant contribution to antibiotic use, research has indicated that a substantial proportion of these prescriptions are not clinically necessary [3-5].

The misuse and overprescription of antibiotics have serious implications beyond individual patients. AMR arises when bacteria evolve mechanisms to survive antibiotic exposure, rendering standard treatments ineffective and leading to increased morbidity, mortality, and healthcare costs. The World Health Organization (WHO) recognizes AMR as one of the most pressing public health threats of the 21st century, driven in large part by the

excessive and inappropriate use of antibiotics across medical and dental practice [6]. Within dentistry, stewardship efforts seek to limit

prescribing to cases with clear clinical indications, thereby mitigating the contribution of dental practice to the growing challenge of AMR.

Table 1: Indications and Preferred Antibiotics in Dentistry. Antibiotics should be used only as adjuncts to definitive dental treatment (e.g., drainage, debridement, or extraction), which remains the primary management of odontogenic infections.

Indication	Preferred Antibiotic	Dose (Adults)	Duration	Notes
Odontogenic infection	Amoxicillin	500 mg q8 h	3 - 7 days (review at 48–72 h)	First-line due to efficacy and safety
Severe infection / spreading infection	Amoxicillin + Clavulanate	875/125 mg q12 h	3 - 7 days	Reserved for severe or suspected resistant infections
Penicillin allergy	Azithromycin	500 mg day 1, then 250 mg daily × 4 days	5 days	Preferred alternative: the choice should consider the severity of allergy and local resistance patterns
No longer a preferred alternative in current practice	Clindamycin	300 mg q6–8 h	3 - 7 days	Last-resort option; use only, if necessary, due to risk of <i>C. difficile</i> infection
Anaerobic infection	Metronidazole	500 mg q8 h	3 - 7 days	Anaerobic coverage only; use in combination with other agents
Acute necrotizing ulcerative gingivitis (ANUG)	Metronidazole	500 mg q8 h	3 days (extend if needed)	Preferred over tetracycline
Endodontic infections (alternative)	Azithromycin	As above	As above	For penicillin allergy; consider allergy severity and resistance
Infective endocarditis prophylaxis	Amoxicillin	2 g PO 30 - 60 min before	Single dose	For high-risk cardiac patients
Surgical prophylaxis	Amoxicillin	2 g PO 1 h pre-op	Single dose	Post-op only if indicated

2. Indications of antibiotics in dentistry

Antibiotics in dental practice are adjuncts, not substitutes for definitive dental treatment such as drainage, extraction, or periodontal therapy. Their use is indicated when there are clinical signs of systemic involvement, rapidly progressing infections, or in high-risk patients such as immunocompromised individuals. Additionally, prophylactic antibiotic therapy is often employed before dental procedures that cause significant oral bleeding, particularly in patients at risk for infective endocarditis or other systemic complications (Table 1) [7-10].

3. The problem: Overuse and misuse of antibiotics in dentistry

Despite clear clinical guidelines, antibiotics are frequently overprescribed or misused in dental practice, contributing to adverse patient outcomes and accelerating AMR. Evidence shows that many prescriptions occur in situations where operative dental treatment alone would be sufficient, where the dose or duration is inappropriate, or where non-clinical factors such as patient pressure influence decision-making. This misuse represents a significant public health concern [11].

3.1 Prescribing when operative treatment alone is sufficient

Clinical evidence indicates that a substantial proportion of dental antibiotic prescriptions are

given in cases where systemic antibiotics are not indicated. Many common dental conditions, including irreversible pulpitis, localized abscesses manageable with incision and drainage, and routine dental caries, do not benefit from antibiotics and are best treated with operative procedures alone. In a large national analysis, antibiotics were often prescribed for diagnoses such as “dental examination” or “dental caries,” which do not inherently require antimicrobial therapy [12]. In fact, only a small fraction (3.4%) of antibiotic prescriptions corresponded to situations with an appropriate diagnostic indication, such as cellulitis or true abscess. This pattern highlights a broad tendency toward antibiotic use even when clinical criteria are not met [12].

3.2 Inappropriate dose and duration

Another common misuse involves improper dosing regimens or unnecessarily prolonged courses of antibiotics. Evidence from clinical reviews and prescribing audits suggests that many dentists select broad-spectrum antibiotics or use longer durations than recommended by evidence-based guidelines for common dental infections [13]. This excessive use increases the risk of side effects, including gastrointestinal disturbances, allergic reactions, and serious conditions such as *Clostridioides difficile* colitis and contributes to the selection pressure that drives the development of resistant bacterial strains [14].

3.3 Influence of patient expectations

Non-clinical influences play a significant role in antibiotic misuse in dentistry. Several studies have shown that patient pressure or expectations can lead clinicians to prescribe antibiotics even when there is no clinical indication. In a survey of practitioners, around one-third of dentists reported receiving frequent requests from patients for antibiotics that were not clinically necessary, and a notable proportion admitted to acquiescing to these demands [15]. This phenomenon reflects broader misconceptions among patients about the role of antibiotics in treating pain or routine dental problems, underscoring the need for better patient education as part of stewardship strategies.

3.4 Self-medication and over-the-counter use

In addition to professional prescribing practices, self-medication with antibiotics for dental pain or swelling is widespread in many regions. Patients may obtain antibiotics without prescriptions or use leftover drugs from prior treatments, often without appropriate diagnosis or guidance. Self-medication not only undermines effective treatment but also fuels resistance by exposing bacteria to suboptimal dosages and durations [16].

3.5 The public health impact

The cumulative effect of these practices is a significant driver of AMR. Overuse and misuse of antibiotics in dentistry contribute to resistance among oral pathogens such as *Streptococcus* spp. and *Enterococcus faecalis*, which complicates both dental and systemic infection management. Rising resistance rates limit the effectiveness of commonly used antimicrobials and may necessitate the use of broader-spectrum or more toxic agents. Overall, addressing poor prescribing practices in dentistry is not just a clinical necessity but a public health imperative, especially as inappropriate dental antibiotic use remains prevalent despite longstanding guideline recommendations [17].

4. Principles of antibiotic stewardship

Antibiotic stewardship refers to coordinated strategies that ensure antibiotics are used appropriately, only when needed and, when used, at the right dose, for the right duration, and using the right drug. These core principles help preserve antibiotic effectiveness, improve clinical outcomes, and minimize adverse effects, including AMR. Appropriate stewardship is especially important in dentistry, where significant evidence shows inappropriate antibiotic use remains common. Up to 90 % of dental antibiotic prescriptions may not

align with guideline-recommended indications, highlighting an urgent need for stewardship action in dental practice [18]. The “Four Rights” of antibiotic prescribing- right drug, right dose, right duration, and right indication- are central to stewardship efforts. According to leading authorities, these principles mean antibiotics should be prescribed only when there is clear evidence of bacterial infection or strong prophylactic need, and clinicians should choose the most targeted agent at the correct dose and shortest effective course to minimize resistance selection and adverse events [19].

4.1 Right indication

Antibiotics should be prescribed only when there is firm clinical evidence of a bacterial infection that cannot be managed by operative dental intervention alone or when evidence-based prophylaxis is indicated. Many common dental problems such as irreversible pulpitis or localized swellings amenable to incision and drainage do not require systemic antibiotics, and reliance on operative management instead aligns with stewardship principles. Dentists should use evidence-based guidelines such as those developed by the ADA to inform decisions. For example, the ADA guideline on antibiotic use for pulpal and periapical conditions recommends against antibiotics for most forms of dental pain and swelling unless systemic signs of infection (like fever or malaise) are present [20].

4.2 Right drug

Choosing the most appropriate antibiotic requires selecting an agent that effectively targets the likely causative organisms while avoiding unnecessary broad-spectrum coverage. Narrow-spectrum agents such as amoxicillin are preferred as first-line therapy for most odontogenic infections due to their efficacy, safety profile, and favourable pharmacokinetics, in accordance with the most recent American Dental Association (ADA) evidence-based clinical practice guidelines [20].

Alternative antibiotics should be reserved for specific clinical situations. In patients with a true penicillin allergy, azithromycin may be used as an alternative. Clindamycin, although previously recommended, is now considered a last-resort option due to its association with an increased risk of *Clostridioides difficile* infection and other serious adverse effects, and should be used only when no safer alternatives are appropriate. Broader-spectrum agents, such as amoxicillin-clavulanate,

should be used judiciously and are best reserved for severe, spreading, or refractory infections rather than routine use. This approach aligns with stewardship principles by avoiding unnecessary broad-spectrum coverage and minimizing the development of antimicrobial resistance. Importantly, antibiotic therapy should be prescribed only when there is clear evidence of systemic involvement or spreading infection and should never replace definitive dental treatment, but rather be used strictly as an adjunct to appropriate operative care [20, 21].

4.3 Right dose and duration

Stewardship emphasizes accurate dosing and limited treatment duration, enough to adequately treat the infection but no longer. Overly long antibiotic courses do not improve outcomes and increase the risk of adverse effects such as *Clostridioides difficile* infections, allergic reactions, and resistance. National stewardship guidance, including CDC recommendations adopted by the ADA, underscores prescribing antibiotics “at the right dose and for the right duration” as critical to minimizing harm and resistance [22].

4.4 International and national stewardship guidelines

4.4.1 American Dental Association (ADA): The ADA and allied professional bodies have developed evidence-based guidelines to clarify when antibiotics are and are not indicated in dental settings. These guidelines emphasize operative management over antibiotics for most dental pain and swelling and reserve prophylaxis for well-defined high-risk scenarios.

4.4.2 World Health Organization (WHO): While not dentistry-specific, WHO antibiotic stewardship frameworks promote core principles applicable to all healthcare settings, including dentistry: ensuring antibiotics are used only when necessary, based on evidence and susceptibility patterns, and stewarded to preserve future effectiveness. These programs encourage implementation of stewardship interventions, education, and monitoring to optimize antibiotic use and slow AMR globally.

4.4.3 National Institute for Health and Care Excellence (NICE): The UK’s NICE guideline NG15 provides broad antimicrobial stewardship recommendations to support health professionals in prescribing antibiotics wisely. Although not dental specific, the guidance underscores the importance of stewardship systems and processes that ensure judicious antibiotic use across care

settings, promoting education, audit, and adherence to evidence-based practices. (Table 2).

4.5 Stewardship in practice

Practical stewardship in dentistry includes:

- Using clinical diagnostic criteria and dental imaging rather than presumptive antibiotic prescribing.
- Prioritizing definitive dental treatment (e.g., drainage, extraction) when appropriate.
- Selecting antibiotics only for appropriate indications and aligning with current guideline recommendations.
- Educating patients about why antibiotics may not be necessary and the risks associated with misuse.
- Monitoring and auditing prescribing patterns to ensure continuous improvement.

Effective stewardship is not static; it requires ongoing education, guideline dissemination, and practice audit to align daily clinical decisions with best evidence and public health goals (Figure 1) [23].

The evidence supporting antibiotic stewardship interventions in dentistry varies considerably. Educational programs and guideline dissemination improve awareness but often produce only modest long-term changes in prescribing behaviour. In contrast, audit-and-feedback systems appear more effective because they provide individualized prescribing data and promote accountability. Delayed prescribing may reduce unnecessary antibiotic use in selected cases, although it can also reinforce patient expectations for antibiotics. Emerging AI-assisted prescribing tools show promise for improving guideline adherence, but evidence in dentistry remains limited. Importantly, most available studies are observational or survey-based, and high-quality randomized controlled trials evaluating stewardship interventions in dental practice are still scarce [22,23].

5. Evidence-based guidelines in dentistry

Evidence-based guidelines emphasize that antibiotics in dentistry should be used only when there is clear evidence of systemic involvement or risk of dissemination, and not as a substitute for definitive local treatment. Authoritative recommendations from the American Dental Association (ADA) and systematic reviews consistently highlight that most pulpal and periapical conditions can be effectively managed with operative dental procedures alone [24, 25].

5.1 When antibiotics are not indicated

5.1.1 Irreversible pulpitis: Irreversible pulpitis is an inflammatory condition of the dental pulp characterized by severe pain but without bacterial dissemination or systemic involvement. Current evidence strongly indicates that systemic antibiotics provide no therapeutic benefit in such cases. A Cochrane systematic review demonstrated that antibiotics do not significantly reduce pain or improve outcomes in irreversible pulpitis, as the condition is best managed by definitive operative treatment such as pulpotomy or root canal therapy

[26]. Similarly, a recent systematic review and meta-analysis confirmed that pulpitis is a localized inflammatory process, and antibiotic therapy is not indicated because there is no systemic infection or bacterial spread [26]. The ADA clinical practice guideline explicitly recommends against prescribing antibiotics for symptomatic irreversible pulpitis, irrespective of whether definitive dental care is immediately available. Instead, clinicians should prioritize local interventions and appropriate analgesia [27].

Table 2. Comparison of ADA, WHO, and NICE antibiotic stewardship recommendations in dentistry

Guideline	Main Focus	Key Recommendations	Strengths	Limitations
American Dental Association (ADA)	Dental antibiotic prescribing	Avoid antibiotics for most localized dental conditions; prioritize definitive dental treatment.	Dentistry-specific and clinically practical.	Limited guidance for medically complex patients.
World Health Organization (WHO)	Global antimicrobial resistance (AMR) control	Promote rational antibiotic use and stewardship across healthcare settings.	Strong public health and global policy framework.	Not specific to dental practice.
National Institute for Health and Care Excellence (NICE)	Antimicrobial stewardship systems	Encourage evidence-based prescribing, audit, and prescribing oversight.	Strong emphasis on implementation and monitoring.	Limited dentistry-specific clinical recommendations.

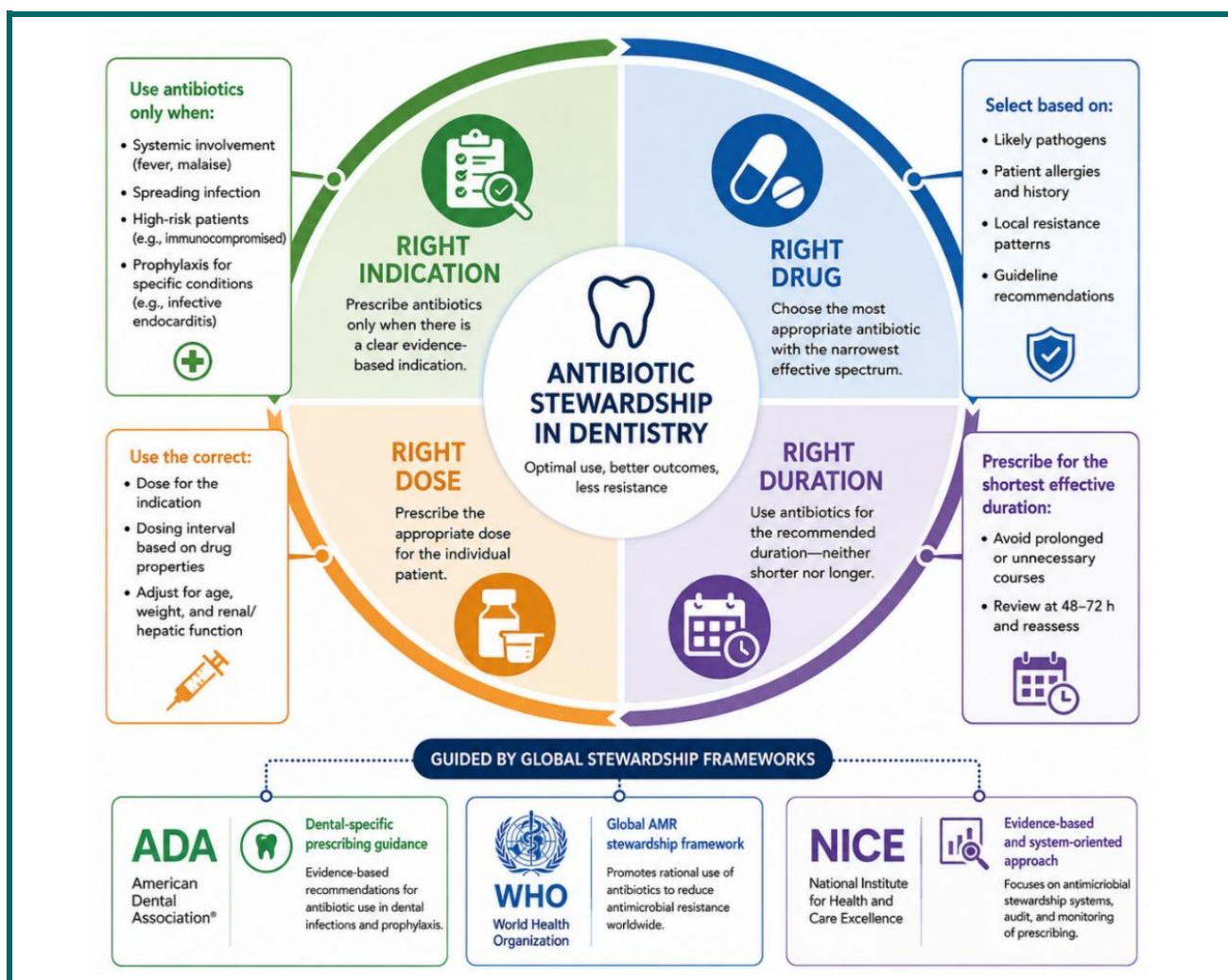


Figure 1. Principles of Antibiotic Stewardship

5.1.2 Localized abscess without systemic involvement: Localized acute apical abscesses confined to the alveolar bone and surrounding tissues, without fever, malaise, or fascial space involvement, also do not require systemic antibiotics. Evidence-based guidelines emphasize that these infections can be effectively treated with local measures such as incision and drainage, root canal treatment, or extraction. Antibiotics offer negligible additional benefit in immunocompetent patients when adequate drainage is achieved [28]. The ADA guideline further states that antibiotics should not be used for localized intraoral swelling when there are no signs of systemic spread, as this may contribute to unnecessary exposure and antimicrobial resistance. Overall, inappropriate antibiotic use in such localized conditions contributes significantly to antimicrobial resistance without improving clinical outcomes.

5.2 When antibiotics are indicated

5.2.1 Systemic Infection (Fever, Diffuse Swelling, Cellulitis): Antibiotics are indicated when odontogenic infections show systemic involvement or evidence of spreading infection. Clinical signs include:

- Fever
- Malaise
- Lymphadenopathy
- Diffuse swelling or cellulitis
- Fascial space involvement

In such cases, the infection extends beyond local confines and poses a risk of serious complications, including airway compromise or systemic sepsis. The ADA guideline recommends the use of systemic antibiotics only when systemic signs are present, in conjunction with definitive dental treatment. Similarly, endodontic literature confirms that antibiotics are appropriate in acute apical abscesses with systemic manifestations, where they act as an adjunct to drainage and elimination of the source of infection [29, 30].

5.2.2 Immunocompromised patients: Patients with compromised immune systems represent a special population in which the risk of infection spread is significantly higher. These include individuals with:

- Uncontrolled diabetes
- HIV/AIDS
- Chemotherapy-induced immunosuppression
- Organ transplantation
- Long-term corticosteroid use

In such patients, even localized infections may progress rapidly, and prophylactic or therapeutic antibiotic use may be justified. The ADA guideline notes that its recommendations against antibiotic use primarily apply to immunocompetent individuals, and clinicians should exercise clinical judgment in immunocompromised patients, where antibiotics may be necessary to prevent systemic dissemination [31].

6. Strategies to improve antibiotic stewardship in dentistry

Improving antibiotic stewardship in dentistry requires a multifaceted approach that targets clinician behaviour, patient expectations, and healthcare systems. Given that a substantial proportion of dental antibiotic prescriptions are inappropriate, implementing structured strategies is essential to optimize prescribing practices and reduce the burden of AMR. Evidence from healthcare systems worldwide suggests that interventions combining education, guideline implementation, and monitoring are most effective in promoting rational antibiotic use [32].

6.1 Adherence to clinical practice guidelines

Strict adherence to evidence-based clinical guidelines is the cornerstone of antibiotic stewardship in dentistry. Guidelines developed by organizations such as the American Dental Association, World Health Organization, and National Institute for Health and Care Excellence provide clear recommendations regarding appropriate indications, drug selection, and duration of antibiotic therapy [33].

Despite the availability of such guidelines, studies consistently demonstrate low compliance among dental practitioners, often due to lack of awareness, habitual prescribing patterns, or perceived patient expectations. Promoting guideline adherence through clinical protocols, chairside decision-support tools, and institutional policies can significantly reduce inappropriate prescriptions. Integration of guidelines into electronic health records and prescribing software further enhances accessibility and real-time clinical decision-making [33].

6.2 Continuing dental education

Continuing Dental Education (CDE) plays a critical role in updating clinicians' knowledge regarding evolving evidence and best practices in antibiotic use. Rapid advancements in understanding

antimicrobial resistance and frequent updates in clinical guidelines necessitate ongoing professional training. Educational interventions, including workshops, seminars, online modules, and case-based learning, have been shown to improve prescribing behaviour and reduce unnecessary antibiotic use. Importantly, CDE programs that focus on practical clinical scenarios, such as management of dental pain and localized infections, are more effective than purely theoretical instruction.

Incorporating antibiotic stewardship modules into undergraduate and postgraduate dental curricula further ensures that future practitioners develop evidence-based prescribing habits early in their careers [34]. Although educational interventions improve clinician awareness regarding antibiotic use, education alone is often insufficient to achieve sustained behavioural change. Evidence suggests that combining education with prescribing audits and stewardship policies is more effective in reducing inappropriate antibiotic prescribing [34].

6.3 Patient awareness and education

Patient expectations and misconceptions about antibiotics are significant contributors to their overuse in dentistry. Many patients incorrectly believe that antibiotics are necessary for pain relief or routine dental infections, leading to pressure on clinicians to prescribe unnecessarily. Improving patient awareness is, therefore, a key component of stewardship. Effective strategies include:

- Clear communication about the limited role of antibiotics in dental conditions.
- Explaining the risks of misuse, including side effects and antimicrobial resistance.
- Providing written instructions or educational materials during consultations

Shared decision-making approaches, where clinicians actively involve patients in treatment decisions, have been shown to reduce demand for antibiotics. Public health campaigns led by organizations such as the World Health Organization also play a vital role in improving community-level awareness about responsible antibiotic use [35, 36].

6.4 Delayed prescribing strategies

Delayed (or “back-up”) prescribing is an evidence-based strategy that can reduce unnecessary antibiotic use while maintaining patient satisfaction. In this approach, the clinician provides a prescription but advises the patient to initiate antibiotic therapy only if symptoms worsen or fail to improve after a specified period.

This strategy is particularly useful in situations where:

- Immediate definitive dental treatment is not available.
- There is uncertainty about disease progression.
- Patients expect a prescription but may not ultimately require antibiotics

Clinical studies have demonstrated that delayed prescribing significantly reduces antibiotic consumption without compromising clinical outcomes. The ADA guideline also supports this approach in select cases, particularly for pulp necrosis with symptomatic apical periodontitis when access to care is limited. Clear instructions and follow-up are essential to ensure appropriate use and prevent misuse of delayed prescriptions [37]. Delayed prescribing can reduce antibiotic consumption while maintaining patient satisfaction, particularly when immediate dental treatment is unavailable. However, some authors argue that strict evidence-based non-prescribing approaches may better prevent unnecessary antibiotic exposure and reduce patient dependence on antibiotics [37].

6.5 Audit and feedback systems

Audit and feedback mechanisms are among the most effective system-level interventions for improving antibiotic prescribing practices. These involve:

- Monitoring clinicians’ antibiotic prescribing patterns.
- Comparing them with evidence-based benchmarks or peer performance.
- Providing structured feedback to encourage improvement.

Studies have shown that clinicians who receive regular feedback on their prescribing behaviour are more likely to align with guideline recommendations. Audit systems can be implemented at institutional, regional, or national levels and may include electronic prescribing audits, peer review systems, and quality improvement programs. In addition, incorporating antibiotic stewardship metrics into clinical performance indicators and accreditation standards can further reinforce responsible prescribing practices [38]. Compared with standalone educational strategies, audit-and-feedback interventions generally demonstrate greater effectiveness because they encourage accountability and continuous improvement. AI-based decision-support systems may further strengthen stewardship efforts in the future, although dental-specific evidence remains limited [38].

6.6 Limitations of current evidence

Despite increasing research on antibiotic stewardship in dentistry, several limitations remain. Most studies are cross-sectional surveys or retrospective analyses, limiting the strength of evidence. Considerable geographic variability in prescribing practices and guideline implementation also makes comparison between studies difficult. In addition, long-term interventional studies evaluating stewardship outcomes are limited, and standardized measures for assessing stewardship success in dentistry have not yet been established. Further prospective and randomized studies are needed to identify the most effective stewardship strategies in dental practice [38, 39].

7. Challenges in implementation of antibiotic stewardship in dentistry

Despite the availability of evidence-based guidelines, the implementation of antibiotic stewardship in dentistry remains inconsistent and challenging. Multiple studies highlight that barriers exist at the individual clinician level, patient level, and systemic level, all of which contribute to continued inappropriate antibiotic prescribing. Understanding these challenges is essential for designing effective stewardship interventions [39].

7.1 Lack of awareness and knowledge

One of the most significant barriers to effective antibiotic stewardship is the limited awareness and understanding among dental professionals regarding appropriate prescribing practices and AMR. A recent cross-sectional study reported that only 16.4% of dentists were aware of antibiotic stewardship principles, indicating a substantial knowledge gap across different levels of clinical experience [39]. Similarly, qualitative research has demonstrated that insufficient knowledge and lack of structured stewardship programs contribute to misinformation and inappropriate prescribing behaviours among dentists [40].

Additionally, global surveys among dental students and practitioners reveal variable confidence in antibiotic prescribing, suggesting that gaps in undergraduate and continuing education persist across different regions. These findings highlight the need for improved integration of stewardship principles into dental education and clinical training [41].

7.2 Time pressure in clinical practice

Time constraints in busy dental practices represent another critical barrier to appropriate antibiotic prescribing. In high-volume clinical settings, dentists

may opt for antibiotic prescriptions as a time-saving measure, especially when definitive dental treatment cannot be performed immediately [42]. Qualitative studies have shown that antibiotics are sometimes used as a “quick fix” or temporary solution when clinicians face scheduling limitations or limited access to emergency care facilities. This practice may be further exacerbated in emergency departments and rural settings, where access to definitive dental treatment is often delayed [42]. Such time pressures can lead to deviation from evidence-based guidelines, reinforcing inappropriate prescribing patterns and contributing to antimicrobial resistance.

7.3 Fear of medico-legal consequences

Fear of potential complications and medico-legal repercussions is a well-documented driver of antibiotic overprescribing in dentistry. Clinicians may prescribe antibiotics defensively to avoid the risk of adverse outcomes, even when clinical indications are not present.

Evidence from qualitative research indicates that many practitioners perceive antibiotics as a “low-risk safety net”, preferring to prescribe them rather than risk disease progression or potential litigation. This risk-averse behaviour is often influenced by:

- Concern about worsening infection.
- Fear of patient complaints or legal action.
- Previous negative clinical experiences.

Such defensive prescribing practices undermine stewardship efforts and contribute to unnecessary antibiotic exposure [43].

7.4 Variability and limitations in global guidelines

Another major challenge is the lack of uniformity and clarity in clinical guidelines across different countries and healthcare systems. While organizations such as the ADA, WHO, and NICE provide recommendations, variations exist in:

- Indications for antibiotic use.
- Drug selection and duration.
- Management of special populations (e.g., immunocompromised patients).

Studies have highlighted that existing guidelines are often limited to specific patient populations, primarily immunocompetent adults, leaving uncertainty in managing medically complex or pediatric patients [44]. Furthermore, inconsistent dissemination and implementation of guidelines result in heterogeneous prescribing practices globally, contributing to ongoing misuse of

antibiotics in dental care. A recent review also identified inconsistent adherence to guidelines as a key contributor to antibiotic resistance in dentistry [45].

8. Future directions in antibiotic stewardship in dentistry

As AMR continues to escalate globally, the future of antibiotic stewardship in dentistry will depend on the integration of advanced technologies, precision diagnostics, and personalized treatment approaches. Emerging innovations aim to enhance clinical decision-making, reduce unnecessary antibiotic exposure, and promote targeted therapy. Key developments include artificial intelligence (AI)-assisted prescribing, point-of-care diagnostics, personalized medicine, and the use of narrow-spectrum antibiotics.

8.1 Role of artificial intelligence (AI) in prescribing decisions

Artificial intelligence has the potential to transform antibiotic prescribing in dentistry by providing real-time, evidence-based clinical decision support. AI-driven systems can analyze patient data, clinical findings, radiographic images, and medical history to assist clinicians in determining whether antibiotics are indicated.

Recent studies suggest that AI-based decision support tools can improve diagnostic accuracy in dental infections, reduce inappropriate antibiotic prescriptions, and enhance adherence to clinical guidelines.

Machine learning algorithms integrated into electronic health records can generate personalized treatment recommendations, minimizing reliance on empirical prescribing. Furthermore, AI can assist in predicting the risk of infection progression, helping clinicians identify patients who may benefit from antibiotic therapy. Although still in early stages within dentistry, AI applications have shown promising results in broader healthcare settings, where they have successfully optimized antimicrobial prescribing and reduced errors. Future integration into dental practice may significantly strengthen stewardship efforts [46, 47].

8.2 Point-of-care diagnostics

One of the major limitations in current dental practice is the lack of rapid diagnostic tools to differentiate between infections requiring antibiotics and those manageable with local

treatment alone. Point-of-care (POC) diagnostics represent a critical advancement in this area. POC technologies aim to provide rapid chairside identification of pathogens and their antimicrobial susceptibility, enabling targeted therapy rather than empirical broad-spectrum prescribing. These tools may include molecular diagnostic assays, biomarker-based tests (e.g., inflammatory markers), and salivary diagnostics.

Emerging evidence suggests that rapid diagnostic testing can significantly reduce unnecessary antibiotic use by improving diagnostic certainty and guiding appropriate treatment decisions. In dentistry, the development of saliva-based diagnostic platforms holds particular promise, offering a non-invasive and efficient method for detecting oral pathogens and assessing disease severity [48, 49].

8.3 Personalized medicine

Personalized or precision medicine represents a paradigm shift in healthcare, focusing on tailoring treatment to individual patient characteristics, including genetic, microbiological, and immunological factors.

In the context of dental antibiotic stewardship, personalized approaches may involve:

- Assessing individual risk for infection progression.
- Identifying patient-specific microbiome profiles.
- Considering comorbidities and immune status.

Advances in genomics and microbiome research have revealed significant variability in oral microbial composition among individuals, which may influence both disease progression and response to antibiotics. Personalized treatment strategies can therefore help clinicians optimize antibiotic selection and minimize unnecessary exposure. Additionally, pharmacogenomics may guide antibiotic choice by predicting patient-specific drug metabolism and risk of adverse reactions, further enhancing safety and efficacy [50, 51].

8.4 Development and use of narrow-spectrum antibiotics

The overuse of broad-spectrum antibiotics is a major driver of antimicrobial resistance. Future stewardship efforts emphasize the development and use of narrow-spectrum antibiotics that specifically target causative pathogens while preserving the normal microbiota. Narrow-spectrum agents offer several advantages:

- Reduced selection pressure for resistant organisms.
- Lower risk of disrupting beneficial microbial flora.
- Decreased incidence of adverse effects such as *Clostridioides difficile* infection.

Research into targeted antimicrobial therapies, including bacteriophage therapy and antimicrobial peptides, is ongoing and may provide alternatives to traditional antibiotics in the future. Clinical guidelines increasingly recommend selecting the most targeted effective agent for odontogenic infections, reinforcing the importance of moving away from empirical broad-spectrum prescribing [52, 53].

9. Conclusion

AMR represents one of the most pressing global health challenges of the 21st century, driven largely by the inappropriate and excessive use of antibiotics across healthcare disciplines, including dentistry. Given that a substantial proportion of dental antibiotic prescriptions are unnecessary or not aligned with evidence-based guidelines, the need for effective antibiotic stewardship in dental practice has never been more urgent. This review highlights that most common dental conditions, such as irreversible pulpitis and localized infections without systemic involvement, can be successfully managed with definitive operative treatment alone, without the need for systemic antibiotics. Conversely, antibiotics should be reserved for clearly defined clinical situations, including cases with systemic involvement or in high-risk patients. Adhering to evidence-based guidelines is essential to ensure optimal patient outcomes while minimizing the risks associated with antibiotic misuse. Dentists play a critical and often underrecognized role in combating AMR. As significant contributors to outpatient antibiotic prescribing, they are uniquely positioned to influence prescribing practices through rational decision-making, patient education, and adherence to stewardship principles. By prioritizing accurate diagnosis, timely definitive treatment, and judicious antibiotic use, dental professionals can substantially reduce unnecessary antibiotic exposure.

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