Open Forum Infectious Diseases

MAJOR ARTICLE

Private Practice Dentists Improve Antibiotic Use After Dental Antibiotic Stewardship Education From Infectious Diseases Experts

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Background. Private practice dentists represent 72% of United States dentists. We conducted a prospective cohort study of private practice dentists comparing antibiotic use before and after dental antibiotic stewardship education by infectious diseases (ID) antibiotic stewardship experts.

Methods. Study phases were as follows: phase 1 (preeducation), 3 months of retrospective antibiotic data and a presurvey assessed baseline antibiotic knowledge; phase 2 (education), dentists attended 3 evening Zoom sessions; phase 3, (posteducation/interventions), 3 months of prospective audits with weekly feedback; phase 4, postsurvey and recommendations to reach more dentists.

Results. Fifteen dentists participated. Ten had practiced >20 years. Presurvey, 14 were unfamiliar with dental stewardship. The number of antibiotic prescriptions pre/post decreased from 2124 to 1816 ($P < .00001$), whereas procedures increased from 8526 to 9063. Overall, appropriate use (prophylaxis and treatment) increased from 19% pre to 87.9% post ($P < .0001$). Appropriate prophylaxis was 46.6% pre and 76.7% post ($P < .0001$). Joint implant prophylaxis decreased from 164 pre to 78 post ($P < .0001$). Appropriate treatment antibiotics pre/post improved 5-fold from 15% to 90.2% ($P = .0001$). Antibiotic duration pre/post decreased from 7.7 days (standard deviation [SD], 2.2 days) to 5.1 days (SD, 1.6 days) ($P < .0001$). Clindamycin use decreased 90% from 183 pre to 18 post ($P < .0001$). Postsurvey responses recommended making antibiotic stewardship a required annual continuing education. Study participants invited ID antibiotic stewardship experts to teach an additional 2125 dentists via dental study clubs.

Conclusions. After learning dental antibiotic stewardship from ID antibiotic stewardship experts, dentists rapidly optimized antibiotic prescribing. Private practice dental study clubs are expanding dental antibiotic stewardship training to additional dentists, hygienists, and patients across the United States.

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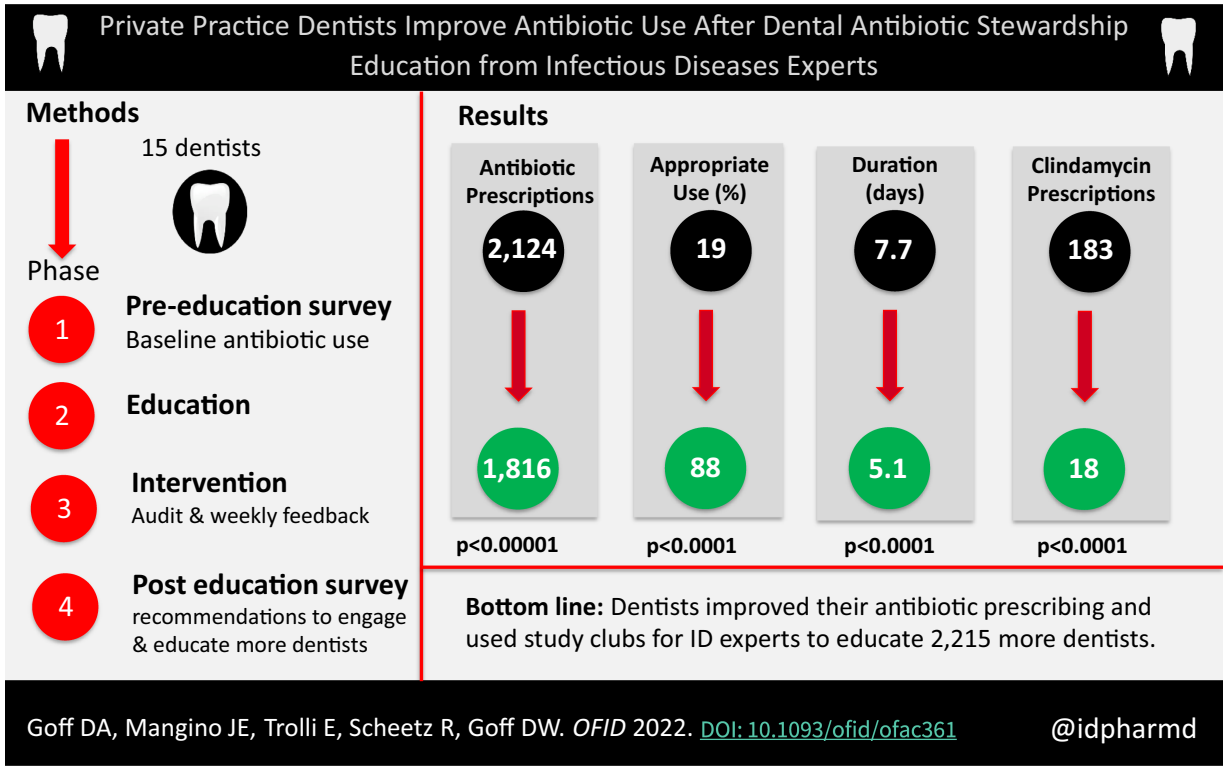
Graphical Abstract



Keywords. antibiotics; behavior change; dental antibiotic stewardship; dentists; education.

Dentists prescribe approximately 10% of all outpatient antibiotic prescriptions in the United States (US), writing >25.7 million prescriptions annually [1]. Dentists are the top prescribers of clindamycin in the US, the most common antibiotic leading to *Clostridioides difficile* infection (CDI) [2]. Clindamycin for dental prophylaxis was removed from the 2016 American Academy of Orthopaedic Surgeons (AAOS) and the 2021 American Heart Association (AHA) guidelines [3, 4]. More than 80% of antibiotic prophylaxis prescribed by dentists was found to be unnecessary [5]. Dental antibiotic prescriptions for treatment are frequently written for 7- to 14-day courses with few data to support these durations [6]. Conflicting scientific evidence, lack of evidence, fear of lawsuits, and lack of knowledge on antibiotic risks contribute to inappropriate antibiotic use [7].

Effective 1 January 2020, outpatient antibiotic stewardship program (ASP) requirements are applicable to Joint Commission–accredited ambulatory care organizations, including those providing dental care [8]. To date, 1 US study has implemented a dental ASP in a College of Dentistry clinic [9]. Other studies assessing appropriateness of dental antibiotics within Veterans Affairs (VA) dentistry and antibiotic prescription health claims databases found low adherence to guidelines [5, 10, 11]. ASPs should expand to private practice dentists, since they represent >72% of US dentists in practice [12]. Unlike VA and academic dentistry clinics, implementing ASP with private practices is fraught with challenges; dentists are not all in 1 building and do not use the same electronic health record. Additionally, private practice dentists own their practice and are not accountable to an ASP committee with associated audits/feedback.

Understanding private practice dentists' antibiotic use is critical to improving their antibiotic use. In 2018, investigators of this study conducted a dental stewardship initiative with private practice dentists and orthopedic surgeons [7]; consensus between dentists and orthopedic surgeons to employ shared decision making and use less prophylaxis was achieved. While it is encouraging that those dentists stated their plan to use fewer antibiotics, it is important to document actual use. Our objective was to assess appropriateness of antibiotics by private practice dentists before and after stewardship education by infectious diseases (ID) ASP experts. We sought their guidance on strategies to engage and educate additional dentists.

METHODS

A prospective multipractice cohort study of dentists was conducted in 4 phases from June 2019 to September 2021. We

aimed to recruit 20 dentists from 1 January 2021 to 28 February 2021. Dentists were initially identified from the 2020 edition of TopDentists [13], a database of greater Columbus, Ohio–area dentists, from peer dental evaluations. Private practice general dentists and specialists (ie, oral surgeons, periodontists, and endodontists) were invited by email, mail and, phone invitation from 1 of 2 dental specialists (an oral surgeon and prosthodontist), coauthors/consultants for this study. Institutional Review Board approval by The Ohio State University was received, and each dentist consented to participate. Practices using paper charts were excluded.

Each dentist assigned 1 office staff member to collect and categorize antibiotic data. In March 2021, investigators provided a Zoom training session to describe how to categorize dental procedures and antibiotic data. Private practice dentists do not document diagnoses using *International Classification of Disease, Tenth Revision, Clinical Modification* or *Current Dental Terminology* codes; therefore, antibiotic use was categorized by procedure as prophylaxis or treatment. Procedures included dental implant, extraction, periodontal or endodontal procedures, restorative procedures, or oral surgery.

In phase 1, baseline/retrospective antibiotic use (1 June–31 August 2019) data were collected into a secure online database and included procedure, indication as prophylaxis or treatment, dose, duration, penicillin allergy, and monthly procedures. The study investigators could view the database in real time. While each dental office started phase 1, dentists completed a 4-part survey (Table 1). Survey responses and analysis of phase 1 antibiotic use were used to develop 3 required 1.5-hour interactive evening Zoom training sessions for phase 2 (education) in March, April, and May 2021, conducted by 2 ID ASP experts with 2 dental consultants. ID ASP experts extensively reviewed dental and medical literature to find evidence-based studies to support dentists' phase 1 antibiotic data. Sessions focused on 5 themes (shown in Figure 1). Sessions were recorded and monitored to assure all dentists participated or reviewed each session prior to the next session.

Table 1. Preeducation Survey of Private Practice Study Dentists

Survey Part	Content
Part 1	Demographics
Part 2	Knowledge of dental antibiotic stewardship
	✓ CDC Core Elements of Outpatient Antibiotic Stewardship ✓ CDC Checklist for Antibiotic Prescribing in Dentistry
Part 3	Knowledge of updated guidelines
	✓ ADA clinical practice guideline on antibiotic use for urgent management of dental pain and swelling ✓ AAOS appropriate use criteria for the management of patients with orthopedic implants undergoing dental procedures ✓ AHA prevention of viridans group streptococcal infective endocarditis
Part 4	Knowledge of antibiotic recommendations for use
	✓ Dental antibiotic studies ✓ Antibiotic choice for penicillin-allergic patients ✓ Antibiotic resistance rates ✓ Antibiotic-related adverse events with a focus on CDI
	Current antibiotic prescribing behavior
	✓ Nonclinical factors that influence use of antibiotics ✓ Management of penicillin-allergic patients ✓ List their standard durations of antibiotic therapy ✓ Preferred sources for new antibiotic information

Abbreviations: AAOS, American Academy of Orthopaedic Surgeons; ADA, American Dental Association; AHA, American Heart Association; CDC, Centers for Disease Control and Prevention; CDI, *Clostridioides difficile* infection.

Principles of implementation and behavior change science were used. During the second learning session, the overall percentage of appropriate phase 1 antibiotic use was shared. Dentists each received individual analysis of their phase 1 antibiotic use, privately, as a report card (Figure 2). This was associated with a 1-on-1 consultation with study investigators to discuss changes to improve their antibiotic use.

Phase 3 (posteducation and interventions) antibiotic data were prospectively collected from 1 June to 31 August 2021. Audit and feedback with weekly 1-on-1 consults were done for dentists who prescribed inappropriate antibiotics. During phase 4 (September 2021), overall phase 3 results were shared; dentists completed a postsurvey and gave verbal feedback to investigators with their recommendations for engaging additional dentists.

Criteria for Appropriate Antibiotic Use

Appropriate use was defined as the right drug, right dose, and right duration based on dental and medical literature, systematic reviews, and in absence of evidence-based studies or conflicting studies, the ID ASP investigators' opinion. The dental literature and the American Dental Association (ADA) do not provide definitive antibiotic guidance for every dental procedure; therefore, we could not define appropriate use based on procedure/diagnosis. Overall "appropriate use" represents prophylaxis and treatment.

Prophylaxis

Prophylaxis was defined as a single dose preprocedure with no postprocedure antibiotics [6]. Antibiotic prophylaxis for infective endocarditis (IE) was considered appropriate, as medical risk for IE was infrequently recorded, whereas prophylaxis for joint implants was inappropriate unless the dentist used shared decision making with those patients instructed by an orthopedic surgeon to take dental antibiotic prophylaxis [3, 6, 14]. "Other prophylaxis" (Table 2) includes dental implants, periodontal and endodontic procedures [15–18], and extractions and was classified as appropriate, as additional medical data (immunocompromised status, pain, and swelling) or surgical data (third molar or necrotic tooth extraction) were not always recorded and literature is conflicting [19]. The 2021 AHA guideline for IE [4] and 2016 AAOS appropriate use criteria [3] were used to determine appropriate antibiotic and dose. For penicillin allergies, both organizations replaced

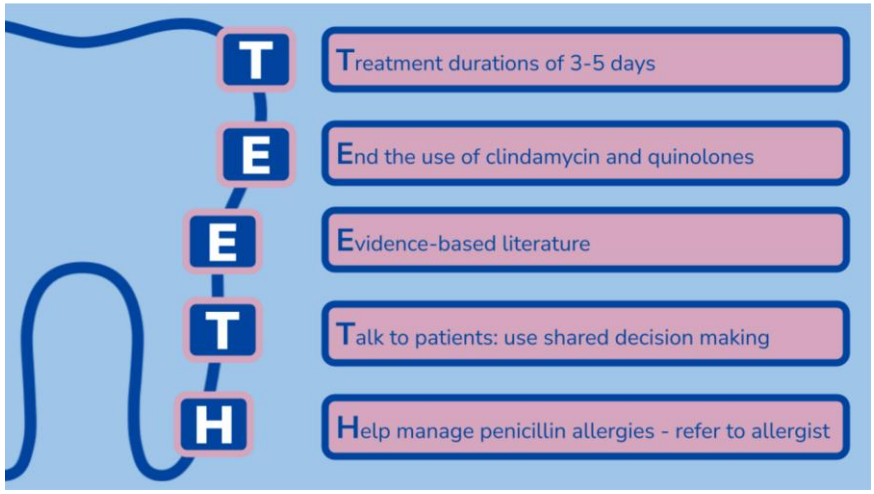


Figure 1. Dental antibiotic stewardship themes.

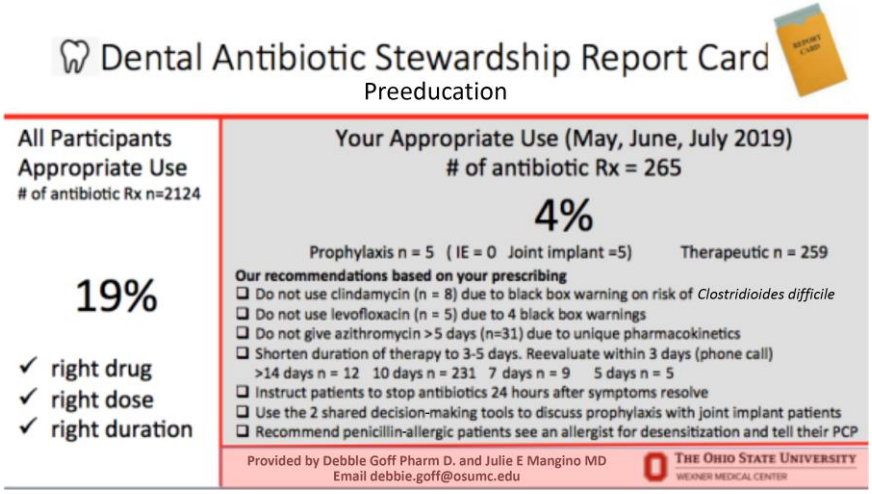


Figure 2. Dental antibiotic appropriate use report card provided to each dentist. Appropriate use is defined as the right drug, right dose, and right duration. This example indicates that 4% of 265 antibiotics prescribed by this dentist were appropriate. Abbreviations: IE, infective endocarditis; PCP, primary care physician; Rx, prescription.

clindamycin with azithromycin, doxycycline, or a cephalosporin; therefore, clindamycin use was inappropriate in our study. Quinolones have 4 black box warnings and are not recommended in dental guidelines; quinolones were considered inappropriate in our study.

Indeterminate Antibiotic Use

Postprocedure antibiotic prescriptions for 2 days were "indeterminate" [6]—that is, neither prophylaxis nor treatment.

Treatment

Prescriptions for ≥3 days with or without prophylaxis were defined as treatment [18]. Antibiotics classified as treatment were defined as appropriate based on duration. Appropriate antibiotic durations were defined as 3–5 days with reevaluation to determine if additional days were required [18]. Durations >5 days were considered inappropriate, unless documentation provided support for additional days. These designations used the ADA Clinical Practice Guideline on antibiotic use for the urgent management of pulpal and periapical-related dental pain and intraoral swelling [18], systematic reviews [15, 16, 20–22], and dental and medical antibiotic studies [10, 11, 17, 23–27] and, in the absence of evidence-based studies or conflicting studies, the ID ASP investigators' opinion. Patients who were receiving antibiotics and referred to a dentist in this study were documented but not included in antibiotic use analysis, since participating dentists did not initiate the prescription.

Table 2. Antibiotic Data Pre/Post Education and Interventions

Categories	Pre, No.	Post, No.	*P* Value	Appropriate Use Pre, %	Appropriate Use Post, %	*P* Value
Dental procedures	8526	9063				
Antibiotic prescriptions[a]	2124	1816	<.00001	19	87.9	<.0001
Clindamycin	183	18	<.0001	…	…	
Quinolones	26	5	.0005	…	…	
Cephalexin	248	50	<.001	…	…	
Doxycycline	67	62	.85	…	…	
Azithromycin	86	234	<.0001	…	…	
Amoxicillin	1320	1286	.0032	…	…	
Prophylaxis	307	301	.31	46.6	76.7	<.0001
Infective endocarditis	28	34	.60	100	100	
Joint implant	164	78	<.0001	0	10.2	
Other[b]	115	189	NA	NA	NA	NA
Treatment	1740	1515	<.0001	15	90.2	<.0001
Duration of therapy, d, mean (SD)	7.7 (2.2)	5.1 (1.6)	<.0001	…	…	
Indeterminate 2-d durations	77	0		…	…	

Abbreviations: NA, not applicable; SD, standard deviation.

[a]Dental specialists had 30 (pre) and 87 (post) patients present on antibiotics prescribed by general dentists. These prescriptions are not included, as they were not prescribed by the study dentists.

[b]Other includes prophylaxis for dental implants, periodontal and endodontic procedures, and extractions.

Statistical Analysis

Summary statistics for continuous variables were calculated and reported as means (standard deviation [SD]) and compared between study groups (preeducation and posteducation/intervention) using Student *t* tests. Categorical variables were summarized as frequencies (percentage) and compared between groups using χ^2 or Fisher exact tests, where relevant. Microsoft Excel was used for data management and descriptive statistics. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corporation, Armonk, New York).

RESULTS

Fifteen dentists (3 general, 2 oral surgeons, 4 endodontists, and 6 periodontists), 13 of whom were male, participated from Ohio, Florida, Nevada, Kansas, and Indiana. Recruitment by email/mail yielded 3 participants, dental consultants recruited 7 peers, and peer-to-peer invitations achieved 5 participants, for 15 total participants. Ten dentists were in practice >20 years, 4 for 11–20 years, and 1 for 6–10 years; 14 offices were urban. Prestudy surveys showed that 14 of 15 dentists were not familiar with dental antibiotic stewardship. Nonclinical factors influencing decisions to prescribe antibiotics included fear of lawsuits and patient request (7 [47%] each) and lack of definitive ADA antibiotic guidance (15 [100%]). Journal articles were identified by 15 participants (100%) for information on antibiotics for prophylaxis and treatment; however, only 2 (13%) read the article "Antibiotic Stewardship" in a dental journal [28]; zero read dental antibiotic studies in nondental journals. All 15 prescribed clindamycin for penicillin allergies; none were aware that clindamycin was no longer recommended by AAOS and AHA for dental prophylaxis [3, 4, 29]. No dentists were aware if their patients had CDI. Most (93%) thought that <5% of patients taking antibiotics experienced adverse events (AEs). No dentists had previously attended lectures by ID ASP experts, nor had access to ID ASP experts. All dentists agreed that use/misuse of antibiotics were drivers for antibiotic resistance; however, none had implemented dental stewardship.

Antibiotic Use Data

The number of antibiotics prescribed posteducation decreased by 14.5%, from 2124 to 1816 ($P < .001$), whereas the number of procedures increased by 6.3% (Table 2). Overall, appropriate use increased 68.9% pre/post from 19% to 87.9% ($P < .00001$). Appropriate prophylaxis increased from 46.6% pre to 76.7% post ($P < .0001$). Prophylaxis in patients with joint implants significantly decreased pre/post from 164 to 78 ($P < .0001$). Dentists used shared decision making with 8 patients posteducation and none preeducation, to decide if the patient was to take prophylactic antibiotics.

Most prescriptions in the preeducation (81.9%) and posteducation (79.6%) phases were for treatment. Treatment appropriateness increased 5-fold from 15% pre to 90.2% post ($P = .0001$), representing a 75.2% decrease in inappropriate antibiotic prescriptions. Antibiotic durations changed within the first week of phase 3 and significantly decreased from 7.7 days (pre) to 5.1 days (post) ($P < .0001$; Figure 3). Posteducation durations >7 days were primarily observed for dental implants with a sinus lift or bone grafting, peri-implantitis, and same-day implants

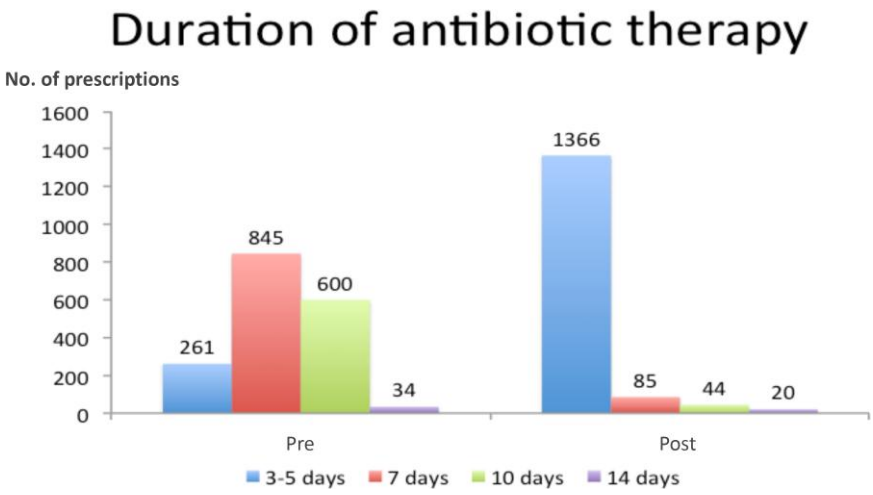


Figure 3. Treatment antibiotic durations before (pre) and after (post) education and interventions.

with necrotic teeth or abscess. Many periodontal procedures involved multiple appointments, and antibiotics were extended till procedure(s) were completed. Postprocedure 2-day prescription durations were 77 preeducation and zero posteducation. Dental specialists had 30 (pre) and 87 (post) patients who presented on antibiotics prescribed by general dentists.

In phase 1, each dentist had preferred standard courses of 5, 7, 10, or 14 days, independent of procedure type. Antibiotic durations were based on prior teaching from dental school and experiential personal preference. Amoxicillin 500 mg every 8 hours was prescribed most frequently pre (62.1%) and post (67.6%). Penicillin allergies were identified in 12.2% (n = 232) preeducation and 12.7% (n = 270) posteducation. Clindamycin decreased 90% (n = 183) pre to (n = 18) post; azithromycin increased by 63.3% (Table 1) Azithromycin 250 mg/day for 10 days was given in 39 patients (pre) and 9 patients (post).

Engaging Additional Private Practice Dentists

Postsurvey responses (N = 15) on the perceived value of dental antibiotic stewardship education followed by audit and feedback were 100% positive with recommendations to make antibiotic stewardship a required annual continuing education, similar to mandatory annual opioid continuing education for some states. Private practice dentists depend on referrals and community engagement to build their practices; therefore, they hosted the investigators to speak on dental stewardship at local and national study clubs and dental societies. Dentists attending these lectures engaged other dentists by sharing their new antibiotic knowledge with peers at additional study clubs. One periodontist and professor of dentistry conducted a video interview posted to YouTube (https://www.youtube.com/watch?V=RULLC3LU8Zg) on "dental antibiotic stewardship lessons learned" with the ID ASP pharmacist and sent it to his network of private practice dentists and patients. To date, these venues engaged an additional 2125 dentists, 105 dental hygienists, and 563 patients in dental stewardship. Dental study participants and attendees at these study clubs have included dental stewardship articles in 475 newsletters to their referring dentists/patients. Additional educational events are ongoing and include dental students.

DISCUSSION

To our knowledge, this is the first US dental antibiotic stewardship intervention study among private practice dentists to improve antibiotic use. Dentists changed their antibiotic prescribing behavior and significantly improved appropriate use by 68.9% after antibiotic stewardship education with audit and weekly feedback interventions by ID ASP experts. Dentists wrote significantly fewer antibiotic prescriptions; decreased use of clindamycin, quinolones, and amoxicillin; and shortened durations of therapy. Importantly, dentists used dental study clubs to engage more dentists, hygienists, students, and patients in dental antibiotic stewardship.

Behavior Change

Private practice dentists, as a majority of US dentists, have little access to ID ASP experts. Nonetheless, dentists are within the Centers for Disease Control and Prevention Core Elements of Outpatient Stewardship; thus, engagement with private practice dentists is fundamental for dental ASPs. Dental guidelines were shared; however, guidelines alone do not improve prescribing [30]. Significant relational dynamics exist in antibiotic decision making and include a focus on risk of lawsuits and fear of infection [7]. Gaining understanding of why dentists prescribe antibiotics was crucial to create this behavior change. Our multifaceted approach proved successful. The first US dental ASP implemented in an academic clinic decreased antibiotic use

72.9% by focusing on standardizing use for acute dento-alveolar conditions [9]. In contrast, our study included antibiotic prescriptions for all dental conditions. The salient theme for inappropriate use was prolonged (>5 days) durations. Dentists prescribed based on the belief that "more is better," clinical experience, or dental training. Thompson et al conducted an ethnographic study and identified 31 dentist factors and 19 patient factors influencing treatment decisions to prescribe antibiotics for acute conditions [31]. Antibiotic beliefs and fear of outcome were among the motivational factors. We shared personal accounts of hospitalized patients with antibiotic AEs, focusing on CDI, and patients with untreatable antibiotic-resistant infections. Dentists have no opportunity to see or care for those hospitalized with antibiotic AEs, CDI, or resistant infections. With these in-hospital experiences and evidence-based literature showing harm from unnecessary antibiotics and benefits of shorter courses for many medical conditions [27], while pointing out lack of dental literature supporting better outcomes with 7- to 14-day courses, dentists rapidly changed behavior by implementing the concepts shown in Figure 1. Behavior change interventions to improve antibiotic prescribing have been previously described [32, 33]. Our combined educational roles and years of ID ASP clinical experience may explain the high acceptance rates in this study.

Durations of Therapy

Promoting shorter courses is a stewardship strategy to reduce selective pressure and AEs by limiting antibiotic exposure. Every day of an unnecessary antibiotic increases resistance risk by 4% per day [34], AEs by 3% risk per 10 days [35] and CDI by 9% per day [36]. Historically, dental literature lacked recommendations for antibiotic durations specific to dental procedures. The 2019 ADA guideline was the first to recommend short courses of 3–7 days for specific dental conditions [18]. It recommends 3 days of antibiotics, and to reevaluate by in-person visit or phone. This guideline states, "Dentists should instruct patients to discontinue antibiotics 24 h after symptoms resolve." Dentists are encouraged away from a "just in case" approach to "when absolutely needed" prescribing [18]. A 2021 study evaluated antibiotic prescribing against this ADA guideline and found that prolonged courses >7 days were frequent [11]. A study of university-affiliated dental clinics in Utah found that the average antibiotic course was 8.3 days [37]. Our phase 1 data showed prolonged durations (>5 days) for all procedures. This may be partially explained by the fact that participating dentists were mostly late career (67% had >20 years in practice); they trained when there was less evidence about long-term consequences of antibiotic misuse, had limited knowledge of shorter courses and escalating antibiotic resistance, and had zero exposure to principles of antibiotic stewardship. One study found that late-career physicians consistently prescribed prolonged antibiotics for >8 days [38]. Two oral surgeons were exceptions in our study; each had >30 years in practice and rarely prescribed postprocedural antibiotics for extractions or implants. They had trained with a respected oral surgeon in 1990 [39], whose mantra was source control as the key to infection prevention. On our last Zoom session, we facilitated peer-to-peer discussions regarding clinical outcomes using long and short antibiotic courses. The dental literature is devoid of studies comparing clinical outcomes of 3–5 vs 7–10 days. We shared rigorous, evidence-based studies providing substantiation for shorter durations in hospitalized patients with serious systemic infections and reemphasized source control.

Adverse Effects of Antibiotics

Our study observed a 90% decrease in clindamycin and 80% decrease in quinolones. Reducing these agents while promoting alternatives for penicillin allergies is critical to dental antibiotic stewardship. A single 600-mg dose of clindamycin can result in CDI and death [40]. Dentists must understand the CDI risk and other serious AEs associated with antibiotics. A Minnesota Department of Health evaluation of community-acquired CDI found that 8% of CDIs were related to prophylaxis for dental procedures [41]. Another study characterizing AEs from unnecessary antibiotic prophylaxis prior to dental visits found that 1.4% were associated with serious AEs, of which 83% required an emergency room visit [42]. After learning that clindamycin was removed from the dental prophylaxis guidelines for IE and joint implants and that quinolones have 4 black box warnings, dentists quickly avoided both agents. This information was shared with their office staff, and these antibiotics were removed as options. In addition, they added CDI to the medical history form. The Peggy Lillis Foundation website (www.peggyfoundation.org) shares the impact of CDI on patient survivors and family members who have lost loved ones from CDI. The inappropriate 10-day courses of azithromycin were addressed by describing azithromycin's unique pharmacokinetic/pharmacodynamic properties and its risk for cardiovascular death [43].

Penicillin-Allergic Patients

Ten percent of the population reports a penicillin allergy but <1% of the entire population is truly allergic [44]. Penicillin allergy was self-reported in approximately 12% of this cohort. Patients with penicillin allergies have higher implant failure rates [45, 46], and failure may lead to longer antibiotic durations. Phase 1 revealed that 100% of dentists prescribed clindamycin for penicillin allergies. During phase 3, dentists stopped prescribing clindamycin and prescribed azithromycin, doxycycline, or cephalexin. Dentists should refer penicillin-allergic patients to an allergist.

Shared Decision Making

Shared decision making between doctors and patients reduces fear and defensive medicine [47]. Our dentists were taught to

use shared decision making with those who demand antibiotics or were instructed by orthopedic surgeons to take lifelong dental prophylaxis. Shared decision making is recommended by the ADA, and tools are available to assist dentists [7]. The Joint Implant Surgeons private practice orthopedic office in Columbus, Ohio, no longer recommends dental antibiotic prophylaxis. We applauded this and inquired how they came to this decision. These orthopedic surgeons attended the 2021 Hip Society Meeting [48] and learned of the United Kingdom study showing no association between dental procedures and joint implant infections [14].

Engaging Additional Private Practice Dentists and Patients

The dental profession does not need to "reinvent the wheel" for dental stewardship to combat antibiotic overprescribing [28]. Figure 1 illustrates 5 antibiotic stewardship themes we recommend.

Our study has limitations. Only 15 dentists participated; most were >20 years in practice. Recruitment by email/mail was unsuccessful, so dental consultants made personal invitations. This could have created bias, and results may not be generalizable to all dentists. However, our participants highly valued their new knowledge and used local and national study clubs, newsletters, and YouTube to expand this knowledge to more dentists and patients. We recommend future dental research recruit with more familiar terminology (ie, "new dental antibiotic guidance" vs "dental antibiotic stewardship"). We also could not determine appropriateness of antibiotic prescriptions by diagnoses, only by procedure. Additionally, there is no consensus for treatment antibiotics for implants, periodontal or endodontic procedures, and extractions, which represented a large proportion of our procedures. Study dentists used longer durations of postprocedure antibiotics for implants with bone augmentation (ie, autogenous bone grafts, guided bone regeneration). Studies are needed to provide definitive guidance to dentists, since >3 million dental implants are placed annually in the US by dentists [49]. If postprocedure antibiotics are prescribed for ≥7 days, this represents >21 million potentially unnecessary antibiotic days. A clinical trial studying the responsible use of antibiotics for periodontal disease is under way [50]; researchers hope it will reduce antibiotic misuse in dentistry.

CONCLUSIONS

Similar to antibiotic stewardship in hospitals, simply asking physicians or dentists to do a better job at prescribing antibiotics does not work. After learning dental antibiotic stewardship from ID ASP experts, dentists rapidly optimized antibiotic use. Private practice dental study clubs are expanding dental antibiotic stewardship training to many more US dentists.

Notes

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Author contributions. D. A. G., J. E. M., D. G., and R. S. designed the study. D. A. G. drafted the manuscript. J. E. M., D. G., R. S., and E. T. revised the manuscript. E. T. managed the online database. All authors agree to be accountable for all aspects of the work.

Patient consent. This study does not include factors necessitating patient consent.

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Potential conflicts of interest. D. A. G. and J. E. M. received a Merck grant, All other authors report no potential conflicts.

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