Misuse of antibiotics has given rise to the growing problem of antibiotic resistance.\textsuperscript{1-3} Even when antibiotics are used correctly, there can be problems because past antibiotic use can be linked to a person’s developing resistant microbes.\textsuperscript{4-6} Therefore, the decision to prescribe an antibiotic is important, and the potential positive results must be weighed against the potential negative consequences.\textsuperscript{7}

Pallasch\textsuperscript{7} reported that there are six possible results of antibiotic use, and only one of them is a positive outcome for the patient. The positive outcome occurs when the antibiotic helps a host’s immune system to gain control and eliminate the infection.\textsuperscript{7} The negative results include toxicity or allergy, superinfection with resistant bacteria, chromosomal mutations to resistance, gene transfer to vulnerable organisms and expression of dormant resistant genes.\textsuperscript{7} Recent data revealed that antibiotic resistance is present in the

\textbf{ABSTRACT}

**Background.** The authors conducted a study to examine the antibiotic prescribing practices of general and pediatric dentists in the management of odontogenic infections in children.

**Methods.** The authors relied on a cross-sectional study design to assess the antibiotic prescribing practices of general and pediatric dentists in North Carolina. The survey instrument consisted of five clinical case scenarios that included antibiotic-prescribing decisions in a self-administered questionnaire format. The participants were volunteers attending one of four continuing education courses. The authors invited all pediatric dentists in private practice to participate in the study, as well as general practitioners who treated children in general practice. The authors compared the practitioners’ responses for each clinical case scenario with the prescribing guidelines of the American Academy of Pediatric Dentistry and the American Dental Association.

**Results.** A total of 154 surveys were completed and returned (55 percent response rate). The mean age of respondents was 47 years, and the mean number of years in practice was 19. Of the 154 overall, 106 (69 percent) were general practitioners and 48 (31 percent) were pediatric dentists. Across the three in-office clinical case scenarios, adherence to professional prescribing guidelines ranged from 10 to 42 percent. For the two weekend scenarios, overall adherence to the professional prescribing guidelines dropped to 14 and 17 percent. Dentists who had completed postgraduate education (n = 73 [51 percent]) were more likely (\( P < .05 \)) to have adhered to published guidelines in prescribing antibiotics.

**Conclusions.** The results of this survey show that dentists’ adherence to professional guidelines for prescribing antibiotics for odontogenic infections in children was low. There appears to be a lack of concordance between recommended professional guidelines and the antibiotic prescribing practices of dentists. Clearer, more specific guidelines may lead to improved adherence among dentists.

**Key Words.** Antibiotics; clinical protocols; infection; guidelines.

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oral flora. Gram-negative anaerobes have appeared in most microbiological studies reviewed in the literature. Most strains tested showed penicillin resistance. In short, the potential negative outcomes make the use and choice of antibiotics crucial to their continued success in treating both dental and medical infections.

ANTIBIOTIC USE

In the United States, more antibiotics than over-the-counter drugs are sold. Dentistry accounts for roughly 200 to 300 million prescriptions annually in the United States. Although dentists do not treat as many patients with antibiotics as do physicians, antibiotic therapy is a valuable option for certain dental infections. Antibiotics and analgesics are the medications prescribed most commonly by dentists, and researchers estimate that 10 percent of antibiotic prescriptions in the United States are related to dental care. There are several indications for the use of antibiotics in dentistry, including treatment of periodontal disease and of severe soft-tissue lacerations. Clinicians treat children with antibiotics primarily to treat oral infections and to prevent bacteremia caused by dental treatment. The goal of antibiotic treatment is to use the smallest amount of drug that is most effective against the organism that is causing the infection. Antibiotic therapy for orofacial infections can achieve excellent results in selected clinical situations, but it should not be the primary treatment modality for orofacial infections unless spreading cellulitis is present. To prevent misuse of antibiotics, dentists need to know the indications and contraindications to prescribing them; the proper dosing schedule; and the risk of allergic and toxic adverse reactions, superinfections and development of antibiotic-resistant organisms. A major distinction between medical and dental conditions is that most dental infections can be treated successfully by removal of the source of the infection.

Professional guidelines for antibiotic use.

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- Oral wound management: Antibiotic therapy should be considered with oral wounds that are at an increased risk of bacterial contamination; examples are soft-tissue lacerations, complicated crown fractures, severe tooth displacement, extensive gingivectomy and severe ulcerations.
- Pulpitis/apical periodontitis/drainage: If a child has acute symptoms of pulpitis and the infection is contained within the pulpal tissue or the immediate surrounding tissue, treatment should be performed and an antibiotic should not be prescribed.
- Acute facial swelling of dental origin: Facial swelling secondary to a dental infection should receive immediate dental attention; depending on clinical findings, treatment may consist of treating or extracting the tooth or teeth in question with antibiotic coverage or prescribing antibiotics for several days to contain the spread of infection and then treating the involved tooth or teeth.
- Dental trauma: Application of an antibiotic to the root surface of an avulsed tooth is recommended to prevent resorption and increase rate of pulpal revascularization; the need for systemic antibiotics with avulsed teeth is unclear.
- Pediatric periodontal diseases: In pediatric periodontal diseases associated with systemic diseases such as neutropenia, Papillon-LeFevre syndrome and leukocyte adhesion deficiency, antibiotic therapy is indicated.

AMERICAN DENTAL ASSOCIATION‡

- Make an accurate diagnosis.
- Use appropriate antibiotics and dosing schedules.
- Consider using narrow-spectrum antibacterial drugs in simple infections to minimize disturbance of the normal microflora, and preserve the use of broad-spectrum drugs for more complex infections.
- Avoid unnecessary use of antibacterial drugs in treating viral infections.
- If treating empirically, revise treatment regimen based on patient progress or test results.
- Obtain thorough knowledge of the side effects and drug interactions of an antibacterial drug before prescribing it.
- Educate the patient regarding proper use of the drug and stress the importance of completing the full course of therapy (that is, taking all doses for the prescribed treatment time).
- Diagnosis and antibiotic selection should be based on thorough medical and dental history.
- Weigh the known risks against the potential benefits of antibiotic use.
- Use antibacterial drugs in a prudent and appropriate manner.

Clinical case scenarios for use of antibiotics.

**CASE 1**
A healthy (ASA I) 9-year-old child, who is a patient of record, visits your office during regular business hours with tooth pain in the lower right quadrant. On clinical examination, you notice a deep carious lesion on tooth T (mandibular right primary second molar). Would you prescribe antibiotics for the following: pain only? symptoms of pain and local swelling with no radiographic evidence of pathology? symptoms of pain and local swelling with radiographic evidence of pathology? symptoms of pain and facial swelling with radiographic evidence of pathology?

**CASE 2**
A healthy (ASA I) 9-year-old child, who is a patient of record, visits your office during regular business hours with tooth pain in the lower right quadrant and a fever of 101°F. On clinical examination, you notice a deep carious lesion on tooth T (mandibular right primary second molar). Would you prescribe antibiotics for the following: pain and fever? symptoms of pain and local swelling with no radiographic evidence of pathology? symptoms of pain and local swelling with radiographic evidence of pathology? symptoms of pain and facial swelling with radiographic evidence of pathology?

**CASE 3**
A healthy (ASA I) 9-year-old child, who is a patient of record, visits your office during regular business hours with tooth pain in the lower right quadrant. The child has no fever. On clinical examination, you notice a deep carious lesion on tooth T (mandibular right primary second molar) along with a draining fistula. Would you prescribe antibiotics for the following: pain and fever? symptoms of pain and local swelling with no radiographic evidence of pathology?

**CASE 4**
The parent of a healthy (ASA I) 9-year-old child, who is a patient of record, calls you on a Saturday afternoon because the child has a chief complaint of tooth pain in the lower right quadrant. Would you prescribe antibiotics for the following: pain only? symptoms of pain and local swelling?

**CASE 5**
The parent of a healthy (ASA I) 9-year-old child, who is a patient of record, calls you on a Saturday afternoon and reports that the child has pain on the lower right quadrant with some warmness of the skin and some swelling that she noticed that morning. Would you prescribe antibiotics for the following: pain only? symptoms of pain and warmness of the skin?

recommended professional practices for prescribing antibiotics. Because the ADA guidelines do not provide clinical information about patients’ signs and symptoms, the expert panel relied on the AAPD guidelines for development of the case scenarios and, largely, determination of adherence. They reviewed the data gathered from the structured interviews and developed the survey instrument. The survey instrument consisted of three main domains: dentist characteristics, practice characteristics and case scenarios (Box 217) involving the decision-making process for prescribing antibiotics during selected clinical situations.

To assist with modifications for survey content, clarity and length, we pilot tested the survey instrument with four general and six pediatric dentists in private practice in the community. The final survey instrument was a three-page, self-administered questionnaire. It included demographic questions pertaining to respondents’ personal characteristics, as well as to their practice characteristics. Box 217 presents the five clinical case scenarios. Each case varied with regard to the clinical signs and symptoms. Clinical signs and symptoms included pain, fever, localized swelling, skin warmth and facial swelling. We also incorporated practice-related factors (such as during regular office hours, after hours, patients of record) into the scenarios. The survey asked dentists whether they would prescribe an antibiotic on the basis of the case information provided.

Data collection and statistical analysis. The two data collectors distributed and collected all of the surveys during professional meetings and continuing education courses. At the course registration, they asked dentists whether they treated children 15 years or younger in their practice and, if so, they asked them to participate in the study.

The Data Capture Services Unit in the UNC-CH School of Dentistry produced the final survey instrument by using TeleForm software. The scannable TeleForm format reduces errors that might have been introduced during data entry. A data collector (W.R.C.) verified each returned survey for completeness before it was scanned. Staff members in the Biostatistical Support Unit at the UNC-CH School of Public Health who work in the School of Dentistry’s Data Capture Services Unit scanned the questionnaires. They then analyzed the data by using statistical software (SAS, Version 7.0, SAS Institute, Cary, N.C.). The primary outcome measure was dentists’ prescribing decisions for each of the five clinical case scenarios.

### RESULTS

A total of 280 dentists attended one or more of the four meetings at which we collected the data. Dentists who attended more than one meeting completed only one survey. The final sample included the 154 dentists who treated children in their practices and agreed to participate.

Table 1 presents dentists’ demographic and practice characteristics. The mean age of respondents was 47 years, with a range of 27 through 68 years. The mean number of years in practice was 19, with a range of one through 43 years. Nearly 30 percent of respondents were pediatric dentists and 70 percent were general dentists. Most respondents were male and alumni of the UNC-CH School of Dentistry. Among the 94 general dentists who answered the question, 23 (24 percent) completed a general practice residency (GPR) or advanced education in general dentistry (AEGD) postgraduate education program.
The majority of dentists worked in a solo private practice setting.

Table 2 presents dentists’ responses to the clinical case scenarios. We deemed dentists to be in adherence with the professional guidelines if they reported that they would prescribe antibiotics for the appropriate collective signs and symptoms. Scenarios 1, 2 and 3 were in-office cases and scenarios 4 and 5 were weekend cases. For the weekend cases, we deemed dentists to be in adherence with the clinical guidelines if they saw the child before prescribing antibiotics and if they prescribed antibiotics for the appropriate collective signs and symptoms.

Overall, adherence rates were low, ranging from 10 to 42 percent. Although not significant, there was a trend toward pediatric dentists’ having higher levels of adherence to professional guidelines than did general dentists. According to the AAPD professional guidelines, dentists should consider prescribing antibiotics when a patient has facial swelling with or without pain, radiographic evidence of pathology or a combination of the preceding. Case 1 represents the collective symptoms of facial swelling, pain and radiographic evidence of pathology. Overall, 26 percent of the dentists in the study were in adherence with the professional guidelines. Among the pediatric dentists, 31 percent were in adherence with the professional guidelines and among the general dentists, 24 percent were in adherence. When we added fever to the list of collective signs and symptoms (case 2), the overall adherence level dropped to 12 percent. When we added local swelling and removed fever from the list of collective signs and symptoms (case 3), the overall adherence level increased to 32 percent of respondents.

Dentists’ adherence to the professional guidelines decreased for the weekend cases. The ADA guidelines state that to prescribe antibacterial drugs, the dentist must “make an accurate diagnosis.” In other words, he or she should see the patient before prescribing antibiotics. Fewer than one-fourth of the dentists reported that they would prescribe antibiotics only after seeing the patient.

Table 3 (page 37) presents the results of the bivariate analyses in which we examined factors associated with dentists’ prescribing practices. For cases 1 and 3, dentists who reported prescribing antibiotics more frequently (weekly or more often) and those who practiced in rural areas were less likely to have adhered to professional guidelines (P < .05). In addition, for case 3, dentists who had completed some type of postgraduate education (pediatric dentistry, GPR or AEGD programs) were more likely to have prescribed antibiotics in accordance with the professional guidelines (P < .05). For the weekend case 5, treating more than 15 children per month and writing prescriptions for antibiotics more frequently were associated with lack of adherence to the professional guidelines. In all five cases, provider type (pediatric dentists versus general dentists) and age were not associated with adherence to the guidelines.

DISCUSSION

This is the first study, to our knowledge, to investigate the use of antibiotics to treat dental infections in children. Overall, adherence to the AAPD and ADA clinical guidelines was low with respect to prescribing antibiotics for odontogenic infections in children. Our findings show a lack of consistency between the way in which dentists in North Carolina treat dental infections in children and the recommended practices set forth in the professional guidelines. Specifically, our results indicate a potential problem in how...
beyond the scope of this investigation, we theorize that patients in rural areas may experience more difficulty accessing dental care and may have much higher dental care needs than patients in urban or suburban areas; therefore, dentists may be treating these patients’ dental infections more aggressively with antibiotics. The survey findings revealed a low percentage of adherence, ranging from 10 to 42 percent. The results of previous investigations of dentists’ adherence to professional guidelines also show low adherence. Nelson and Van Blaricum reported that dentists and physicians had low adherence (32.9 percent) when prescribing antibiotics for subacute bacterial endocarditis coverage. Although one might conclude that the participants were unaware of, or unwilling to adhere to, professional guidelines, there may be another explanation for our findings. The professional guidelines may lack clear direction for certain clinical situations. The ADA guidelines do not include clinical scenarios to illustrate prescribing practices. Although most clinical situations are specific to the patient, the guidelines might be more helpful if they con-

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Responses to clinical scenarios: adherence to professional guidelines* (N = 154).</th>
</tr>
</thead>
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<tr>
<td>CLINICAL SCENARIOS AND RESPONSES†</td>
<td>OVERALL ADHERENCE TO GUIDELINES, NO. (%) OF DENTISTS (N = 154)</td>
</tr>
<tr>
<td>Case 1</td>
<td>Prescribe Antibiotics Only for Pain, Facial Swelling and Radiographic Evidence of Pathology</td>
</tr>
<tr>
<td>Case 2</td>
<td>Prescribe Antibiotics Only for Pain, Facial Swelling and Radiographic Evidence of Pathology</td>
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<tr>
<td>Case 3</td>
<td>Prescribe Antibiotics Only for Pain, Facial Swelling and Radiographic Evidence of Pathology</td>
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<tr>
<td>Case 4</td>
<td>Would See Patient Before Prescribing Antibiotics and Prescribe Antibiotics Only for Pain and Facial Swelling</td>
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<tr>
<td>Case 5</td>
<td>Would See Patient Before Prescribing Antibiotics and Prescribe Antibiotics Only for Pain, Warmness of Skin and Facial Swelling</td>
</tr>
</tbody>
</table>

* Sources: American Academy of Pediatric Dentistry Council on Clinical Affairs, American Dental Association Council on Scientific Affairs.
† The guidelines-recommended response is below the case number.

clinicians are using antibiotics to treat dental infections in children.

We hypothesized that there would be a difference in antibiotic prescribing practices between general dentists and pediatric dentists because the latter treat children more often and usually have more years of education through their residency programs. In addition, the AAPD guidelines offer more specific guidance than do the ADA guidelines (Box 1). In four of the five clinical case scenarios, pediatric dentists’ reported prescribing practices were more closely aligned with the recommended professional guidelines compared with the prescribing practices of general dentists; however, the results were only modestly better for pediatric dentists and none of the differences were statistically significant (P > .05). However, we did find significant differences (P < .05) in adherence to the clinical guidelines according to location of the dental practice. Dentists who reported practicing in rural areas were less likely to prescribe antibiotics in accordance with the clinical guidelines than were those practicing in urban or suburban areas. Although the exact reasons for this finding are beyond the scope of this investigation, we theorize that patients in rural areas may experience more difficulty accessing dental care and may have much higher dental care needs than patients in urban or suburban areas; therefore, dentists may be treating these patients’ dental infections more aggressively with antibiotics.

The survey findings revealed a low percentage of adherence, ranging from 10 to 42 percent. The results of previous investigations of dentists’ adherence to professional guidelines also show low adherence. Nelson and Van Blaricum reported that dentists and physicians had low adherence (32.9 percent) when prescribing antibiotics for subacute bacterial endocarditis coverage. Although one might conclude that the participants were unaware of, or unwilling to adhere to, professional guidelines, there may be another explanation for our findings. The professional guidelines may lack clear direction for certain clinical situations. The ADA guidelines do not include clinical scenarios to illustrate prescribing practices. Although most clinical situations are specific to the patient, the guidelines might be more helpful if they con-
tained representative clinical cases to illustrate recommended prescribing patterns. The AAPD guidelines appear to be more specific than the ADA guidelines, but these too could be expanded or explained further. Moreover, given the significance of this issue, both organizations could undertake more active roles in educating their members.

With regard to dentistry, local drainage often may be sufficient to treat orofacial infections. This may involve removal of the infected tooth to achieve drainage through the socket or drainage through an incision in the area. Clinicians should consider antibiotics as an adjunct to treatment when there are signs of systemic involvement such as diffuse swelling. Although no clear evidence exists regarding the optimum duration of antibiotic therapy, the AAPD Council on Clinical Affairs recommends treatment be continued for a minimum of five days post-improvement or resolution of the patient’s symptoms. However, evidence from the medical literature is challenging the longer duration of antibiotic therapy. Singh and colleagues examined patients in an intensive care unit and found that those who received a shorter (three-day) course of antibiotic therapy experienced fewer instances of antimicrobial resistance, superinfections or both compared with patients who received the longer standard antibiotic therapy (15 versus 35 percent, respectively).

Antibiotic resistance. Antibiotic resistance occurs when bacteria modify themselves via mutations or by exchanging resistance determinants so they can survive even in the presence of antibiotics. Some researchers argue that reduction in antibiotic resistance can occur only after a substantial reduction in antibiotic use has taken place. Widespread use of antibiotics by health care professionals and people in the livestock industry has resulted in an alarming increase in the prevalence of drug-resistant bacterial infections; moreover, the increase in antibiotic resistance has contributed substantially to the morbidity and mortality associated with infectious diseases.

Investigators in several studies found that children treated with an antibiotic were more likely to be colonized soon thereafter with bacteria resistant to the same antibiotic. More importantly, it appears that some type of resistance has been developed for all currently available antibiotics. Dentists and their medical colleagues can help address this growing and potentially devastating problem by prescribing antibiotics only when appropriate and necessary to resolve an infection.

The demographic data gathered were not inconsistent with expectations for a survey of North Carolina dentists. Most respondents attended UNC-CH for dental school, their mean age was 47 years and they had been in practice for a mean of 19 years. Almost the entire sample reported taking some type of solo telephone calls or sharing calls for after-hours emergency cases. In addition, most of the dentists worked in solo or group practices. Most dentists identified their practice as being in a suburban or urban location within the state. Amoxicillin was the drug of choice for treating dental infections. Almost 90 percent of the sample reported that they did not write prescriptions often for dental infections.

Study limitations. We need to consider these results in light of some study limitations. The cross-sectional design limited our ability to draw
causal inferences. Because the survey was self-administered and based on clinical case scenarios, responses may have been susceptible to response bias. The dentists, who were participating in continuing education courses where the surveys were distributed, may not have been a representative sample of dentists in North Carolina. They may have been more informed and more motivated to learn about new ideas in dentistry. In addition, dentists who completed this survey may have been more comfortable with the topic. In the aggregate, these limitations suggest that dentists’ adherence to the guidelines for antibiotic use may be worse than the findings reported here indicate. The power of the study is another limitation. Although a few trends were evident, the sample size was small and, thus, inferences were difficult.

Despite these limitations, this study has several strengths, including being the first, to our knowledge, to report on this topic of importance and clinical relevance. Little is known about antibiotic prescribing practices of dentists in the United States, and almost nothing is known about prescribing practices in treating children. The study results provide preliminary data for one state regarding the extent to which dental professionals are adhering to professional guidelines for prescribing antibiotics for children with dental infections. The data also indicate factors (such as geographic location) associated with prescribing practices. Understanding these factors will help shape educational strategies and the development of future professional guidelines.

This study sets the stage for future research. We obtained self-reported data from dentists in North Carolina, which is a first step to understanding their antibiotic prescribing practices. Future research should include a more randomized approach with more participants to increase statistical power. In addition, investigators should examine antibiotic prescribing practices of dentists in an adult population. Practice-based networks would be an excellent research environment for further study of this topic.

CONCLUSION

The results of this study show a low adherence among general and pediatric dentists to professional guidelines for prescribing antibiotics for odontogenic infections in children. There appears to be a lack of concordance between recommended professional guidelines and the antibiotic prescribing practices of dentists. Clearer and more specific professional guidelines may lead to improved adherence. ■

Disclosure. None of the authors reported any disclosures.