



COVER STORY

Antibiotic prescribing by dentists has increased

Why?

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The discovery and use of antibiotics has averted many deaths, transformed medical practice, and provided new tools to public health for communicable disease control.¹ Today, these gains are at risk of being reversed, owing to natural selection for resistant bacteria. With few immediate prospects of new antibiotic classes, investigators should focus attention on preserving the value of antibiotics currently in use through active surveillance and antimicrobial stewardship.^{2,3} The results of ecological studies have shown that the overuse of antibiotics at the population level leads to resistance.^{4,5} Antimicrobial stewardship efforts in the hospital and community sectors are informed by surveillance of antibiotic use over time.⁶ Since 2001, the Canadian province of British Columbia (BC) has emulated European jurisdictions and established surveillance



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ABSTRACT

Background. Although the overall rate of antibiotic prescribing has been declining in British Columbia, Canada, the authors conducted a study to explain the increased rate of prescribing by dentists.

Methods. The authors obtained anonymized, line-listed data on outpatient prescriptions from 1996 to 2013 from a centralized, population-based prescription database, including a variable coding prescriber licensing body. Analyses used Anatomical Therapeutic Classification standard codes and defined daily dose (DDD) values. The authors normalized prescribing rates to the population and expressed the rates in DDDs per 1,000 inhabitants per day (DID). The Canadian Dental Association released a webinar that invited correspondence from dentists about the drivers of the trend.

Results. From 1996 to 2013, overall antibiotic use declined from 18.24 DID to 15.91 DID, and physician prescribing declined 18.2%, from 17.25 DID to 14.11 DID. However, dental prescribing increased 62.2%, from 0.98 DID to 1.59 DID, and its proportionate contribution increased from 6.7% to 11.3% of antibiotic prescriptions. The rate of prescribing increased the most for dental patients 60 years or older. Communication from dentists in Canada and the United States identified the following explanatory themes: unnecessary prescriptions for periapical abscess and irreversible pulpitis; increased prescribing associated with dental implants and their complications; slow adoption of guidelines calling for less perioperative antibiotic coverage for patients with valvular heart disease and prosthetic joints; emphasis on cosmetic practices reducing the surgical skill set of average dentists; underinsurance practices driving antibiotics to be a substitute for surgery; the aging population; and more dental registrants per capita.

Conclusions. Emerging themes for dental prescribing should be explored further in future studies; however, themes already identified may guide priorities in antibiotic stewardship for continuing dental education sessions.

Practical Implications. Antibiotic prescribing should be reviewed to make sure that we are compliant with guidelines. Most practitioners will find opportunities to prescribe less often and for shorter durations.

Key Words. Antibiotics; antimicrobial stewardship; prescribing; dentists.

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TABLE 1

Community antibiotic prescribing, according to profession in British Columbia, Canada.

PROFESSION*	PERCENTAGE OF RETAIL ORAL ANTIBIOTIC PRESCRIPTIONS IN 2013	RATE OF UTILIZATION AT FIRST YEAR OF PRESCRIBING IN DATA		RATE OF UTILIZATION (DID) IN 2013	PERCENTAGE CHANGE IN UTILIZATION RATE (FROM FIRST YEAR OF PRESCRIBING TO 2013)	MEAN DDD‡ PER PRESCRIPTION 2013
		Year	DID†			
Physicians and Surgeons	87.52	1996	17.25	14.11	-18.20	10.63
Dentists	11.27	1996	0.98	1.59	62.24	9.33
Pharmacists	0.38	1996	5.20×10^{-3}	0.05	900.00	8.57
Podiatrists	0.10	1996	9.05×10^{-3}	0.01	55.56	8.78
Midwives	0.04	1998	9.42×10^{-5}	4.45×10^{-3}	4.84×10^3	8.41
Nurses	0.59	2005	1.96×10^{-4}	0.09	4.29×10^4	9.67
Naturopathic Physicians	0.10	2010	0.01	0.06	500.00	35.20

* Data for optometrists are not presented in this table and accounted for 0.001% of prescriptions in 2013.
† DID: Defined daily doses per 1,000 inhabitants per day.
‡ DDD: Defined daily dose.

for antimicrobial use. Data inform educational messaging on antimicrobial use for physicians and the public. Investigators have noted a 12.7% reduction in the overall rate of prescribing antibiotics between 1996 and 2013.⁷

Antibiotic stewardship efforts within the health care community traditionally have focused on physicians as prescribers, yet other health care professionals in BC also may prescribe, a practice that has yet to be assessed in Canada.^{8,9} These prescribers include dentists, nurse practitioners, and naturopathic physicians; however, because the latter 2 types of clinicians prescribe fewer than 1% of all the prescriptions, we evaluated the prescribing practices of dentists, the second most active prescribing profession.

METHODS

The University of British Columbia Institutional Review Board approved the protocol (certificate H09-00650). All outpatient prescriptions in BC are entered in the BC PharmaNet database.¹⁰ We obtained anonymized, line-listed data, which included a variable coding for the licensing body of the prescriber, for all oral antibiotic prescriptions from 1996 to 2013. We conducted analyses in SAS (SAS Institute) and Excel (Microsoft), using the World Health Organization's Anatomical Therapeutic Classification standard codes and the defined daily dose (DDD), a unit of drug consumption measurement that is independent of different drug preparations. The DDD is the assumed average maintenance dose per day for a drug used for its main indication in adults and does not reflect the recommended or prescribed daily dose. We normalized the rates of prescribing to the BC population¹¹ and expressed in DDDs per 1,000 inhabitants per day (DID).

We conducted analyses for overall antibiotic use by profession and also for rates of prescribing of drug classes and individual drugs by dentists. Mean DDD per prescription was calculated as a proxy for the length of time that the antibiotics were prescribed. Because BC PharmaNet contains all outpatient prescriptions for the population of BC, statistical inference was not required to assess generalizability from a sample. We assessed the significance of trends by using the Spearman rank correlation.

To inform an understanding of possible reasons for prescribing, we broadcast a webinar from the Canadian Dental Association that described trends in dental use. One author (D.M.P.) logged and organized the return e-mail communications according to theme.

RESULTS

Antimicrobial prescriptions. In 2013, BC practitioners wrote 2.6 million antibiotic prescriptions, of which physicians contributed 87.5%, dentists 11.3%, nurse practitioners 0.60%, pharmacists 0.40%, podiatrists 0.10%, naturopathic physicians 0.10%, and midwives 0.04% (Table 1).

Figure 1 illustrates the temporal trends in prescribing by profession. From 1996 to 2013, overall antibiotic use in BC declined from 18.24 DID to 15.91 DID. Prescriptions by physicians declined significantly, by 18.2%, from 17.25 to 14.11 DID ($P < .001$). For dentists, there was a substantial and statistically significant increase of 62.2%

ABBREVIATION KEY. AAOS: American Academy of Orthopaedic Surgeons. ADA: American Dental Association. BC: British Columbia. DDD: Defined daily dose. DID: Defined daily doses per 1,000 inhabitants per day.

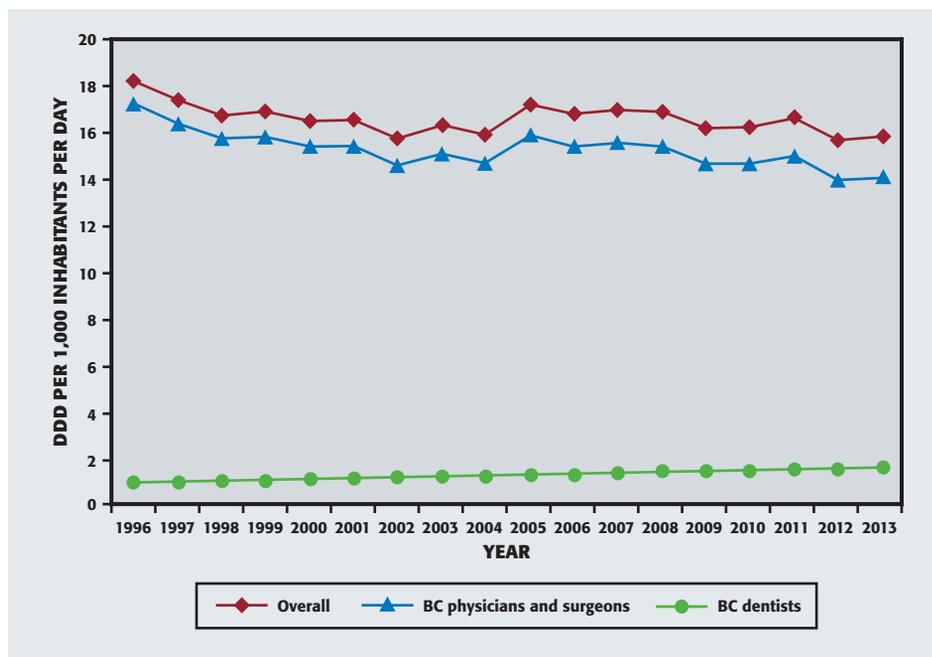


Figure 1. Rate of antibiotic use by prescribing profession, British Columbia (BC), 1996-2013. All trends over time presented in this figure are statistically significant according to the nonparametric Spearman rank correlation ($P < .001$). DDD: Defined daily dose.

in the rate of prescribing, from 0.98 DID to 1.59 DID ($P < .0001$). The percentage of antibiotic use provided by dentists increased from 5.4% to 10.0% of DID, and the percentage of prescriptions provided by dentists increased from 6.7% to 11.3%.

Figure 2 and Table 2 depict trends in dental antibiotic prescribing by drug class and by leading agents. The increase in overall antibiotic prescribing is driven largely by the use of penicillin beta-lactams, which increased 71.6% between 1996 and 2013 (Figure 2). Also, there were increases in the use of the class of macrolides and lincosamides and of the quinolone class of antibiotics, with concurrent decline in the use of trimethoprim-sulfamethoxazole and cephalosporins.

In 2013, amoxicillin and clindamycin were the most commonly used individual agents in dentistry, at 1.26 DID and 0.12 DID, respectively (Table 2). Although the use of these agents has increased markedly since 1996; in 2013, the use of simple penicillin V has declined substantially and accounts for only 0.09 DID, or 5.6% of use. The use of amoxicillin and enzyme inhibitor combinations has increased more than 2,000% between 1996 and 2013.

A breakdown of dental antibiotic use by patient age group (Figure 3) reveals that BC residents aged 40 to 59 years had the highest rate of consumption from 1996 to 2009 (1.39-1.90 DID). However, BC residents 60 years or older have had a more rapid increase in dental antibiotic use, and their use surpassed the use of 40- to 59-year-olds

in 2010. By 2013, BC residents 60 years or older had the highest rate among all age groups (2.17 DID). We also observed a steady increase in the 15- to 19-year-old age group, from 0.78 DID in 1996 to 1.78 DID in 2013. In 2013, rates of use were similar for men and women, at 1.59 and 1.60 DID, respectively (data not shown).

We assessed the mean number of DDD per prescription in 2013 for dentists as a proxy for duration of therapy. Dentists prescribed in the same range (9.33 DDD per prescription) as most other practitioners. The outlying profession for this metric was naturopathic physicians, who prescribed a

mean of 35.20 DDD per prescription; we have discussed this observation with members of that profession. The mean DDD per prescription for all other professions fell within a range of 8.41 to 10.63 DDD (Table 1).

Themes identified in correspondence after the webinar. As of December 3, 2015, 1,798 practitioners (2% from the United States and the remainder from Canada) had accessed the webinar. Sixteen dentists (25% from the United States and 75% from Canada) contributed 30 communications to one of the authors (D.M.P.) after the event. Eleven explanatory themes emerged, most of which were supported by the literature (Table 3). Themes included unnecessary prescription for periapical abscesses and irreversible pulpitis; increased use with dental implants and associated complications; slow adoption of new guidelines calling for less perioperative antibiotic coverage for patients with valvular heart disease and prosthetic joints; emphasis on cosmetic practice potentially reducing the surgical skill set of the average dentist; underinsurance driving antibiotics as a substitute for surgery; an aging population; and more dental registrants per capita in BC.

DISCUSSION

Our study is the first in Canada to describe antibiotic prescribing rates by dentists. Although physicians account for providing the most antibiotic prescriptions, our study results showed a substantial increase in the proportionate and absolute prescribing rates by dentists in

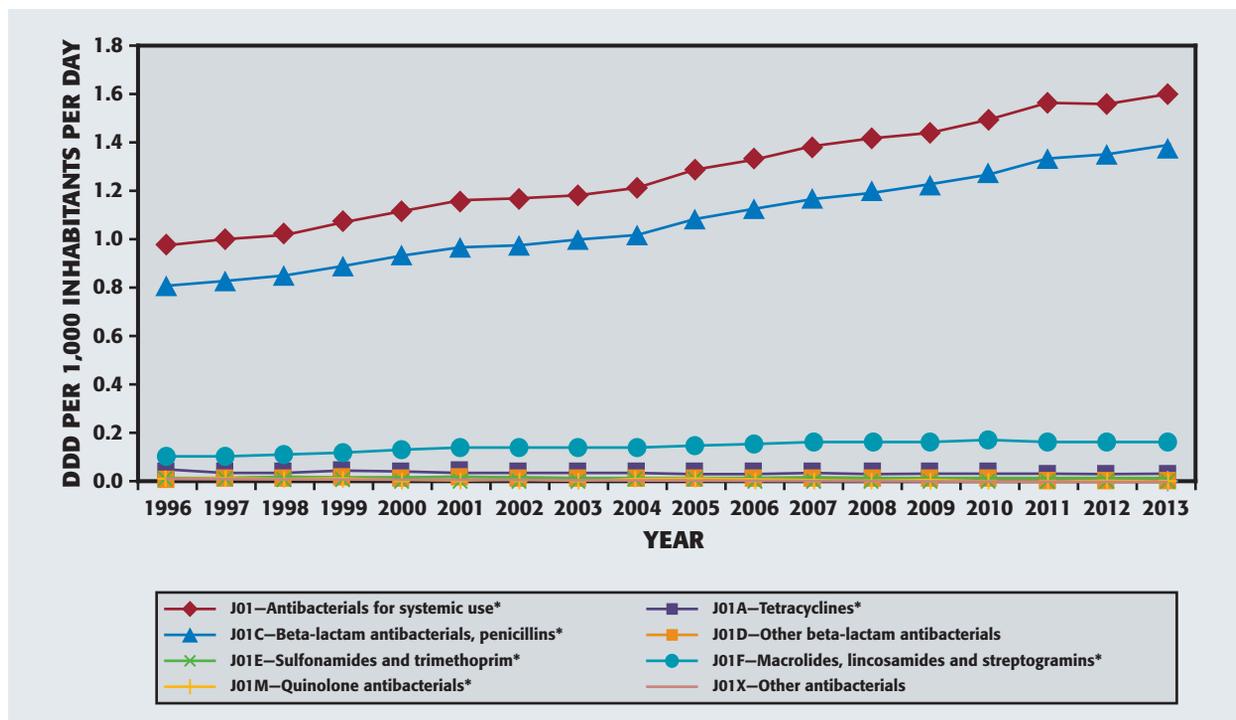


Figure 2. Rate of antibiotic use by antibiotic drug class among prescriptions by dentists, British Columbia, 1996-2013. Anatomical Therapeutic Classification standard codes for antibiotic drug classes are included. *: Trends over time are statistically significant according to the nonparametric Spearman rank correlation ($P < .001$). DDD: Defined daily dose.

BC. Although dentists in BC contributed only 11.3% of the antibiotic prescriptions in 2013, the absolute increase in dental prescribing was sufficient to substantially blunt the expected decline in antibiotic use at a population level associated with observed changes in physician practice.

Our study results also showed that the prescribing of the narrow spectrum agent, penicillin V, has decreased significantly, whereas the use of amoxicillin and combinations of amoxicillin and enzyme inhibitors has increased. This is of concern because penicillin V continues to be recommended as a first-line agent for many dental indications and it retains suitable coverage across much of the oral flora. Dentists in the United States contributed a similar proportion (10%) of all antibiotic prescriptions,¹² whereas the dental contribution was lower (7-8%) in Europe.¹³⁻¹⁸ Investigators in other countries also have reported the dominant use of amoxicillin.^{19,20}

The increase in antibiotic prescribing by dentists that we observed in our study is of concern as it is occurring at a time when the use of recommendations and guidelines should be producing a decrease.^{21,22} One of the

TABLE 2

Utilization rate, according to antibiotic drug and percentage change, 1996 to 2013, dentists, British Columbia.

DRUG*	RATE OF UTILIZATION (DID†) IN 1996	RATE OF UTILIZATION (DID) IN 2013	PERCENTAGE CHANGE FROM 1996 TO 2013
Amoxicillin	0.52	1.26	143
Clindamycin	0.014	0.12	789
Phenoxymethylpenicillin (Penicillin V)	0.27	0.09	-67
Amoxicillin and Enzyme Inhibitor	1.49×10^{-3}	0.04	2,240
Doxycycline	0.023	0.024	4.3

* Only drugs that accounted for greater than 1% of utilization by dentists in 2013 are presented.
† DID: Defined daily doses per 1,000 inhabitants per day.

themes we heard from participants in the webinar centered on overprescribing for periapical abscesses and irreversible pulpitis. An acute periapical abscess is a localized infection that causes an intense inflammatory response, resulting in severe and throbbing pain. In 2005, dentists debated whether reducing the inflammatory

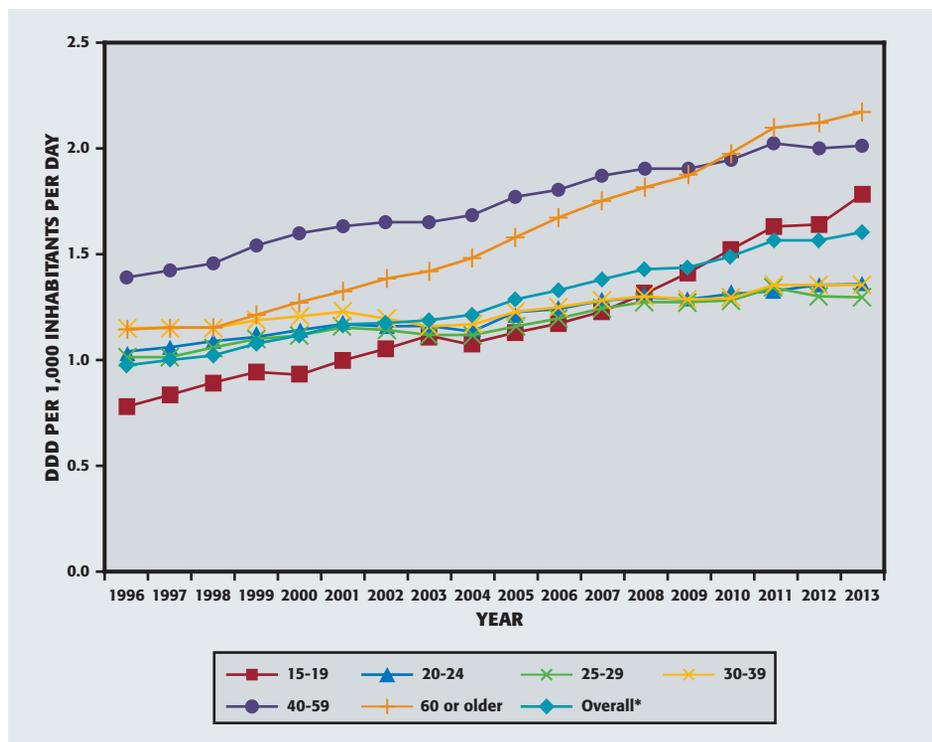


Figure 3. Rate of antibiotic use by age group among prescriptions by dentists, British Columbia, 1996-2013.

*: Includes prescriptions for patients 14 years or younger, which account for 3% to 6% of all dental prescriptions per year. All trends over time presented in this figure are statistically significant according to the nonparametric Spearman rank correlation ($P < .001$). DDD: Defined daily dose.

response by using nonsteroidal anti-inflammatory drugs or eliminating the bacteria by using antibiotics was the most appropriate treatment response.²³ However, in 2013, the investigators of a systematic review and meta-analysis concluded that periapical abscesses should be drained through a pulpectomy or incision and drainage and that the use of antibiotics was of no additional benefit in terms of the outcomes of pain or infection.²⁴

Another identified reason for overprescribing is the slow or incomplete adoption of new guidelines calling for a decreased use of perioperative antibiotics in patients with valvular heart disease and prosthetic joints. Recommendations for prophylaxis in patients with valvular heart disease were revised in 2007 and 2008.²⁵⁻²⁷ Prophylaxis against infective endocarditis is not recommended for the American Heart Association–defined moderate-risk group of cardiac patients. Even for patients at high risk of experiencing complications (for example, patients who have mechanical valves) prophylaxis is not recommended for a number of minor procedures, including routine anesthetic injection; dental radiography; or placement, removal or adjustment of prosthodontic and orthodontic devices. Given the revised guidelines, we would expect a decrease in the use of amoxicillin after 2008, but because we did not observe

such a decrease, we conclude that there has been poor translation of guidelines into practice.²⁸ Furthermore, although prophylaxis is not recommended for patients with nonvalvular vascular devices (for example, pacemakers, defibrillators, shunts, grafts, and stents), anecdotal evidence suggests that dentists often prescribe prophylactic antibiotics for patients with these devices.²⁹

Guidelines and advice for prophylaxis before undergoing invasive dental procedures for patients with total joint replacement began to emerge in the 1970s.³⁰ Attention focused on the role of dental procedure–induced bacteremia in late prosthetic joint infections, and orthopedic surgeons, infectious

disease physicians, and dentists widely supported recommendations for antibiotic coverage for all patients with total joint replacement.³¹ Although support for prophylaxis appears to have diminished among infectious disease specialists,³² Canadian orthopedic surgeons and dentists surveyed in 2013 indicated that they prescribed antibiotics prophylactically (77% and 71%, respectively) to patients before undergoing invasive dental procedures,³³ and that they had differences in opinion regarding the duration of the practice; orthopedic surgeons were significantly more likely to advocate lifelong coverage (63%), whereas only 22% of dentists favoured that practice—most dentists endorsed prophylaxis for the first 2 years after total joint replacement.

Since the 1970s, recommendations for coverage for orthopedic patients have undergone numerous iterations, resulting in confusion among practitioners and patients.^{34,35} In 1997, the American Academy of Orthopaedic Surgeons (AAOS), the American Dental Association (ADA) and the Infectious Diseases Society of America published a consensus-based advisory statement, which was revised in 2003.³⁶ The statement recommended prophylaxis for defined “high-risk” conditions and for all patients during the first 2 years after

TABLE 3

Explanatory themes identified by 16 dentists for increasing rates of antibiotic prescribing.	
THEME (NO. OF RESPONDENTS)	SPECIFIC COMMENTS
Treatment of Periapical Abscess (6)	Definitive treatment should be surgical.
Treatment of Irreversible Pulpitis (4)	Definitive treatment should be surgical.
Prophylaxis for Third-molar Surgery (1)	Not available.
Increase in Prescription in Association With Dental Implants and Bone Grafting (4)	Large growth in use of dental implants, especially by general practitioners, may be driving an increase in prescribing for prophylaxis and treatment of complications.
Perioperative Prophylaxis for Patients With Prosthetic Joints (5)	Practitioners slow to adopt new, more restrictive guidelines. Orthopedic surgeons also may be ambivalent about new guidelines.
Perioperative Prophylaxis for Patients With Valvular Heart Disease (6)	Practitioners slow to adopt new, more restrictive guidelines.
Shift to Cosmetic Practice (3)	Dentists with cosmetic practices may be more likely to refer patients to other practitioners for surgery and use antibiotics while the patient is waiting. May have less experience with repeat endodontic procedures.
Insufficient Awareness of Dentists' Role in Antibiotic Resistance (2)	Most public and media awareness campaigns focus on physician use. Comparably few articles in the dental literature focus on <i>Clostridium difficile</i> and other complications of antibiotic use.
Impact of Underinsurance (2)	Practitioners may be more likely to prescribe an antibiotic for underinsured patients than commit more office time to surgical management.
Aging Population (2)	Older patients may be receiving more implant surgery.
More Dental Registrants per Capita (2)	An increase in registrants should not increase a population's requirement for antibiotics. However, an increase in procedures may drive increase in prescription.

total joint replacement. In 2012, the AAOS and ADA published a systematic review and accompanying guideline.³⁷ Although the evidence reviewers found no association between dental procedures and prosthetic joint infections, and in fact, noted that daily activities such as chewing, brushing, and flossing induced many more bacteremias than dental procedures, the guidelines offered no clear recommendations for or against antibiotic prophylaxis.³⁷ Citing existing evidence, as well as addressing a concern about frequent, widespread antibiotic use, both the Canadian Dental Association and the ADA have taken the position that prophylactic antibiotics are not recommended before undergoing dental procedures to prevent prosthetic joint infections.^{38,39}

Changing patterns in use according to patient age are instructive. Increases in prescribing within well demarcated age strata mean that changes in use cannot be blamed on an aging population alone. Rather, we must look for changes in practice that affect the rate of prescribing in each observed age stratum. Our analysis of the input from our dental correspondents contributes to the hypothesis that a more rapid increase in use has occurred in patients 60 years or older due to the growth in implant surgery and its distribution to more practices. We also saw increasing use in patients aged 15 to 19 years, which may be linked to third-molar extraction. Surgical removal of mandibular third molars is one of the most frequently performed procedures by both general dentists and oral surgeons; the use of postoperative antibiotics is common for this procedure.⁴⁰ However, although there is some evidence that antibiotics reduce the

complication rate, there is equal evidence to the contrary.^{40,41} Some clinicians believe that pain and complications after extraction are related to inflammation rather than to an actual infection that requires an antibiotic.^{40,41}

Coverage for medical care is funded publicly and is essentially universal in BC and across Canada, but the same is not true for dental services. Underinsurance is a substantial problem, as it also may be in the United States. A decision to surgically manage an underinsured patient can result in considerable lost income for a dentist; this situation creates an incentive toward choosing the quick option of offering an antibiotic prescription, for example, even when this choice does not represent definitive treatment.

We also have seen a clear increase in the ratio of dentists to the population in BC. On the surface, the burden of maxillofacial infections requiring treatment with antibiotics should not increase because of a higher ratio of practitioners to patients. If, however, the increased availability of practitioners drives the rate of dental procedures, and procedures, in turn, drive prescribing, then there may be a logical connection.

Going forward, a number of opportunities could be leveraged to reverse the upward trend in dental prescribing. First, it will be relatively simple to continue to plot trends in use by professions as indicators for programs that could change use patterns. For example, practitioners have indicated that there is a clear opportunity to reduce rates of perioperative antibiotic prophylaxis. Second, successful approaches to stewardship

in medicine also can translate to dentistry. Dentists are adept at offering symptomatic relief, which is a key element of care when any practitioner is refraining from prescribing antibiotics. Third, explaining to patients the risks of antibiotic use is important. Risks include experiencing hypersensitivity, *Clostridium difficile* infection,⁴² and disruption of the normal healthy microbiota, but also extend to a risk of affecting contacts and community through selection for more resistant organisms.^{9,43} Practitioners also may find it helpful to share informational links to community stewardship sites with their patients.

Our study had some important limitations. Data came from 1 province, British Columbia, Canada. Unlike medical care, dental care is not publicly insured in Canada, so trends in practice may be similar to those occurring in the United States. Because dentists in BC cannot bill the Medical Services Plan of British Columbia, a process that requires the submission of a diagnostic code, we could not directly infer the indications for antibiotic prescription by linking data as we can for physicians. However, as we found in the described experiences of the 16 dentists who responded to the webinar, dentists were quick to engage in e-mail correspondence and the themes they identified were well supported by the literature. Because our study was not a large, formal survey, however, the themes we have identified should be validated further by investigators of future, larger studies.

CONCLUSIONS

We documented a rather alarming increased rate of the prescription of antibiotics by dental practitioners. When maximizing antibiotic stewardship efforts in populations, it is important to consider the role of all prescribing professions, with an initial focus on dentistry. ■

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