Methodology for the development of a national Dental Practice-Based Research Network survey on dentist's beliefs and behaviors concerning antibiotic prophylaxis

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Background. Dentists are high prescribers of antibiotics for both treatment and prevention of infection, although there are few guidelines to aid clinicians. Given the worldwide concerns about unnecessary use of antibiotics, there is a need for a better understanding of dentists' use of these drugs for antibiotic prophylaxis (AP) to prevent distant site infections (i.e., infective endocarditis and prosthetic joint infection).

Objective. The aim of this study was to develop and implement an effective, self-reporting, cross-sectional, survey instrument that optimized the response rate and maximized reliability and validity for determining the beliefs and behaviors of a large and nationally representative group of generalist and specialist dentists concerning their use of AP.

Study Design. A 15-question survey (58 items) was developed in a structured process by a multidisciplinary team and configured for automated online dissemination to 3584 national Dental Practice-Based Research Network (DPBRN; hitherto referred to as "Network") practitioners. The implementation phase consisted of 3 waves of greater than 1000 Network members. Additionally, 47 randomly selected dentists were surveyed twice to assess test–retest reliability.

Results. Of 3584 eligible Network members, 2169 (60.5%) completed the survey. The age and geographic distributions of responders was similar to those of dentists in the 2019 American Dental Association census. Furthermore, test–retest weighted kappa values for the survey were acceptable (median 0.56; interquartile range 0.42–0.64).

Conclusions. We developed a highly structured survey with a high response rate and good reliability that will allow us to obtain unique data on dentists' beliefs and practices regarding AP prescribing. (Oral Surg Oral Med Oral Pathol Oral Radiol 2020;130: e29–e37)

Prescribing practices for antibiotics in general have become an important issue in public health and clinical practice. The use of antibiotic prophylaxis (AP) before invasive procedures is intended to reduce bacteremia and potentially devastating outcomes of distant site infections. The origins of this practice include the focal infection theory[1–4]; older animal studies; and hundreds of case reports. Clinical studies performed in the past 30 years have indicated that many dental procedures can be sources of transient bacteremia. This led to a rise in the use of AP for patients thought to be at risk for distant site infections.[5,6]

There are multiple factors that could influence the prescribing practice, beliefs, and behavior with regard to AP, including: (1) the growing concern about the development of antibiotic resistance, even from a single dose[7]; (2) adverse drug reactions, including infection by *Clostridium difficile*[7,8]; (3) diverging opinions on, and compliance with, formal AP guidelines[9]; (4) the large number of patients who would need to receive AP to prevent 1 case of distant site infection[10]; (5) the lack of scientific evidence to support AP use[10]; and (6) the significant financial cost and inconvenience associated with AP use in the dental office.[11,12] The most longstanding, and controversial, application of AP use is for prevention of infective endocarditis (IE) in patients with specific cardiac conditions[13] and of hip and knee infections in those with prosthetic joints.

Despite specific guidelines from the American Heart Association (AHA) and other authoritative bodies, lack of data demonstrating a causal relationship between dental procedures and IE or prosthetic joint infections has resulted in lack of consensus on AP.[14–19] A study by Durkin et al. found that AP prescribing by dental specialists, in contrast to physicians, remained stable

Statement of Clinical Relevance

We used a multistep process to develop a survey instrument to determine the beliefs and behaviors of a large, national cohort of dentists with regard to their use of antibiotic prophylaxis for patients at risk for developing distant site infections.

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during 2013 through 2015 in the United States, emphasizing the need for public health efforts to improve AP prescribing practices.[20]

We could find no studies of dentists' beliefs and opinions regarding AP use in patients at risk from invasive dental procedures, and we determined that a well-designed survey instrument would provide highly useful data to understand where problems exist, design solutions (e.g., educational programs), and help with ongoing efforts toward antibiotic stewardship. Surveys of health care professionals typically have lower response rates than those of the general public.[21] Low response rates have been associated with increased survey demands (long or complex questionnaires); insufficient range of response options; concerns over confidentiality; and increased work load on health care professionals.[21] Thus, in their elegant study, Funkhouser et al. demonstrated that higher response rates require minimization of questionnaire length and work load, improving the perception of confidentiality and follow-up of nonresponders.[21]

Our objective was to focus on the methodologic considerations necessary for the development of a rigorous single-time-point, self-reporting, cross-sectional survey instrument targeting a representative group of members of the national Dental Practice-Based Research Network (DPBRN; hitherto referred to as "Network"), whose overarching goal is to foster research endeavors to improve clinical practice.[22] Web-based tools, timeline management logistics, and human resources (study team and regional coordinators) were used to improve dentist response rates and maximize validity and reliability in assessing the beliefs and behaviors of the Network members regarding their use of AP.

MATERIALS AND METHODS

Overall study design and Network setting

The Network is a consortium of over 4000 dentists from 6 regions of the United States: Midwest, Northeast, South Atlantic, South Central, Southwest, and Western. The group members include general dentists (74%) and specialists (26%) in endodontics, periodontics, prosthodontics, orthodontics, pediatric dentistry, dental public health, and oral and maxillofacial surgery. Detailed information on the Network and its purpose and mission statement have been provided elsewhere.[23] Because of the infrequency with which oral pathologists and oral radiologists are involved in prescribing AP, these 2 groups were not invited to participate in the present study.

The distribution of Network members across the 6 regions the United States at time of the survey is shown in Supplemental Table I. The University of Alabama at Birmingham Institutional Review Board (IRB) served as the central IRB of the national DPBRN, from which a waiver of signed consent was sought and granted. Dentists completing the survey were remunerated with $50 for their participation. The cross-sectional AP survey instrument timeline consisted of two 9-month phases: (1) survey development and (2) survey implementation, involving a multistep process as described below.

Development of the AP survey instrument (months 0−9)

Stage 1. A multidisciplinary study team was assembled and consisted of dentists (practitioners and researchers) and qualitative research experts in psychology, informatics, statistics, and survey methodology.[24] The team also included experienced data managers and research coordinators to collect and transfer data and ensure effective follow-up in the survey implementation.

During brainstorming sessions, the study team established that to produce an effective survey instrument and optimize the response rate, the following topics would need to be addressed: (1) frequency of AP prescribing, (2) knowledge and perception of AHA guidelines, (3) decision criteria to implement or change AP practices, and (4) the perception of risk/benefit ratio and associated comorbidities. For further optimization, we ensured proper communication with the numerous regional research coordinators within each of the 6 Network geographic regions involved in the study. Indeed, the regional coordinators' focus is to disseminate Network communications, establish and maintain working relationships, and promote the overall goals of the Network.

Ad hoc team members established the timeline and secondary documentation and/or contributed to the development of a preliminary survey draft consisting of 90 questions. A consolidated and more refined survey version was then created; it contained 37 multiresponse questions (187 items) covering a broad range of issues initially thought to be important. A reduction in the number of questions was accomplished through numerous brainstorming sessions among subject experts via conference calls. This focus on reducing the number of questions and the formatting of these questions was intended to prevent survey fatigue and deliver a high response rate by ensuring that the survey could be completed in less than 20 minutes.

The survey version of 37 multiresponse questions (187 items) was tested on a focus group of 11 dentists who were not involved in the questionnaire development. They completed a cognitive "think aloud" test,[25,26] in which focus group members were recorded when reading the questions aloud and verbally expressing what they thought the question addressed before reading the answer choices aloud. They were also

asked to provide feedback as to whether the answer choices were reasonable and fully exhaustive. Thus, a first version of the survey instrument was developed to organize the questions based on content, and a second version was developed to organize the questions based on cognitive demand and content. The latter version allowed the study team to determine if there was a method to reduce cognitive demand, prevent survey fatigue, and thereby further increase the response rate.

Stage 2. Once the organization of the survey questions was complete, a survey draft containing 37 questions underwent an informal review process by the National Institute of Dental and Craniofacial Research. The ensuing draft, a finalized survey instrument consisting of 15 multiresponse questions, was then approved. Participant-facing documents (i.e., email invitation, reminder emails, etc.) were reviewed by the central IRB of the national DPBRN, University of Alabama (after approval by the regional IRBs) and the IRB at the Carolinas Medical Center − Atrium Health. While the survey instrument required participants to provide their consent online, this study underwent expedited IRB review and waiver of consent documentation because the study poses minimal risk to patients.

Stage 3. The final survey instrument of 15 multiresponse questions comprised 58 items, including 8 with 5-point Likert scales (2 with 4 parts, i.e., substantial subquestions), 6 with 2 to 5 multiple choices, and 1 with a percentage slider bar. These questions covered (1) eligibility (active, US-licensed dentist) and consent; (2) knowledge and perception of AHA and prosthetic joint guidelines; (3) decision criteria to implement or change AP practices; (4) perception of risk/benefit ratio and associated comorbidities; and (5) survey closing questions (see Supplemental Table II). Demographic characteristics were not included in the survey because these data were available from the Network.

The approved survey instrument and the invitation emails were configured into the electronic data capture tool for data collection and management in the Research Electronic Data Capture (REDCap) program.[27] Final testing and system checks were performed to ensure compatibility with various Internet browsers before launch.

Automated survey implementation and recruitment (months 10−18)

Eligible dentists were identified from the Network's enrollment questionnaire data, which included contact information (including active email addresses) for member dentists randomly selected for participation. As part of the enrollment process, practitioners complete an enrollment questionnaire to describe themselves, their practice(s), and their patient populations.[28] During the 9-month implementation phase, invitations to participate in the AP survey were only delivered to active Network members licensed to practice dentistry in the United States and currently engaged in dental practice. All eligible dentists received an automated study invitation email from the principal investigator, explaining the study and inviting them to participate.

The automatic email invitation, sent at a designated time through REDCap, contained unique hyperlinks for each network provider to access and complete the survey, which included a "Save and Return" feature in REDCap. To optimize participation, invitations resulting in autogenerated undeliverable email messages were tracked and brought to the attention of the appropriate regional coordinator to acquire the most up-to-date contact information. If requested by the practitioner, surveys were mailed to a physical address with prepaid return envelopes.

Survey and network enrollment data were linked by using participant IDs. The list of eligible dentists was split into 3 waves to ensure a smooth enrollment and data collection, improve workload feasibility for the coordinators, and prevent system crashes when the surveys were sent out via REDCap. The size and composition of the first wave of invitations were determined on the basis of pilot data from approximately 40 respondents.

The 3 waves of invitations could be adjusted by following the response rates live in REDCap and by using a random generator tool to reduce bias. In addition, for the 3 waves of invitations, region-specific quotas were applied to ensure representative sampling of both generalists and specialists from the 6 defined network regions.[28] Demographic characteristics of the participants were obtained from the Network's enrollment database.

Approximately 2 weeks after the initial survey invitation was disseminated, an email reminder was directed to those members who had not yet responded. Two weeks after the first reminder, a second email reminder was directed to the members who had still not completed their survey. The Network's regional coordinators then assisted the study team in delivering a third email reminder from their designated regional coordinator (RC) if the invited participants had not completed the survey within 7 to 10 days after the second reminder. The coordinators continued to contact nonresponders (e.g., via phone, fax, email, postal mailing, etc.) until that specific wave's response time ended, 10 weeks from the wave's launch date. Thus, invited dentists who had not responded within approximately 10 weeks were considered nonresponders, and their survey links were deactivated.

Completion of the survey indicated that practitioners read the informed consent information, and this implied

consent, in compliance with the central IRB of the University of Alabama DPBRN. Participants were assigned a unique identification number, which was used to maintain confidentiality for study records and to organize data transcripts. Contact information was removed from the final merged data set, and data were stored/saved by using unique participant IDs. All survey data were collected and housed in the Carolinas Medical Center – Atrium Health REDCap Survey Management System.

Statistical considerations

Assuming that 60% of the total DPBRN dentists (N = 4002, as of January 7, 2017; see Supplementary Table I) were eligible, we anticipated that about 2400 participants (1805 generalists and 595 specialists considered in this study) would be enrolled. This would result in a margin of error (MOE) of 3.15% (+/− 0.34 [standard deviation]), on average, per region (generalists [n = 3010] and specialists [n = 992] combined), 1.46% for general dentists and 2.55% for specialists (all regions combined), at 95% confidence level (per online MOE survey tool at https://aytm.com/pages/mes).[29] The percentage of MOE describes how closely answers from the 60% responders represent the "true value" in the entire DPBRN population. It is assumed that an MOE of 5% for a 95% confidence level is an acceptable standard for this survey, although higher MOEs can be anticipated when analyzing dentist subcategories or if a lower response rate is obtained.

To assess test−retest reliability, 47 of the initial survey responders were randomly selected to complete the online survey twice (approximately 2 weeks after initial completion). Nearly all main survey items were on the Likert or a categorical scale, except for 2 items with percentiles; these items were categorized into segments because percentiles represent a rough estimate. The agreement reliability for these 47 participants was determined by using Cohen's kappa and weighted kappa statistics. Percentage of agreement was defined as the number of items with the same responses from test and retest, divided by the total of the main body of survey items, and multiplied by 100. Descriptive summary statistics including frequencies, means, medians, standard deviations, and percentiles were determined. The analysis was performed by using SAS Enterprise Guide version 7.1 on the platform of SAS version 9.4 (SAS Institute Inc., Cary, NC). A 2-tailed z-test for the 2 population proportions was used to determine differences in responders' representations regarding age and geographic distributions (significance level alpha = 0.05).[30]

RESULTS

Primary results associated with the methodology are described below. The extensive results pertaining to the beliefs and behaviors of dentist about AP use will be published separately, with the present methodologic report serving as a reference.

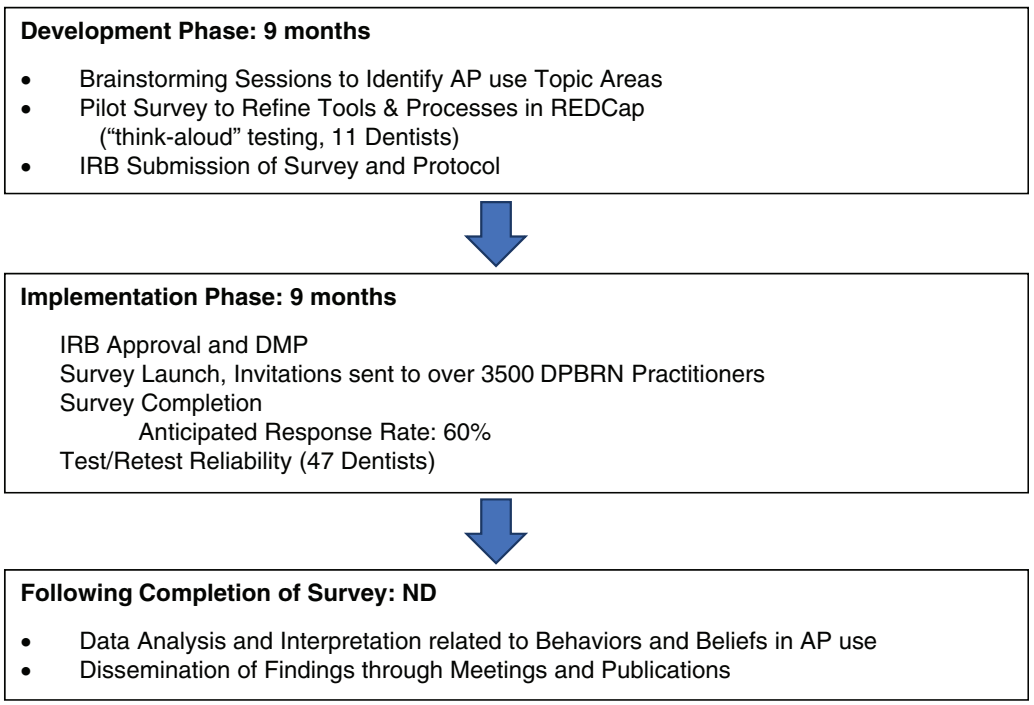

Fig. 1. Antibiotic prophylaxis (AP) survey study design. Summary of key steps of the AP survey study design consisting of a 9-month development phase and a 9-month implementation phase. The "think aloud" process is designed to improve the readability and accessibility of the survey. *DMP,* data management plan; *IRB,* institutional review board; *REDCap,* Research Electronic Data Capture.

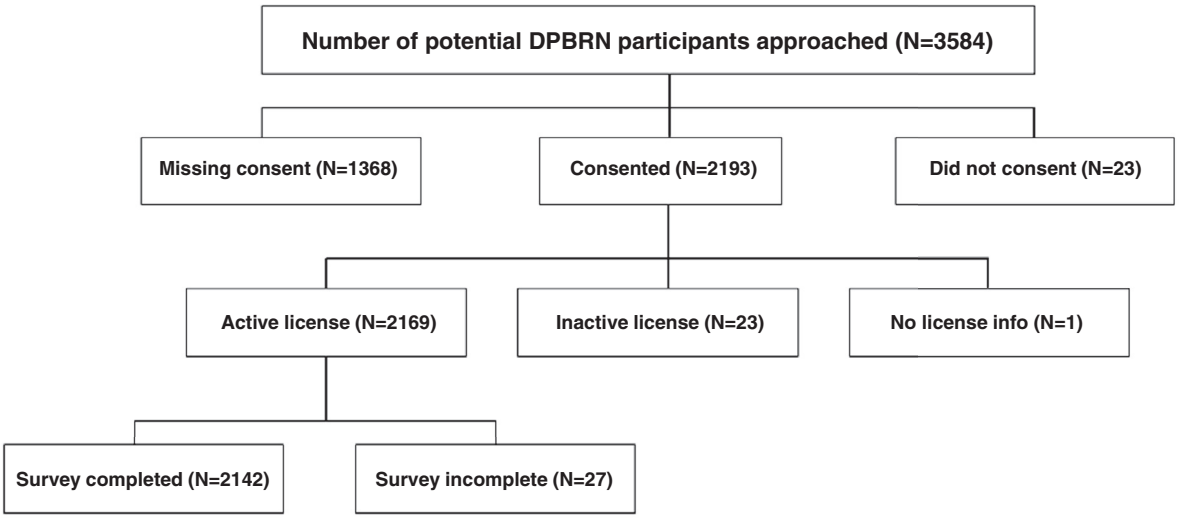

Fig. 2. Screening and selection process of antibiotic prophylaxis (AP) survey eligibility. A total of 3584 Dental Practice-Based Research Network (DPBRN) members were sent emails to inform them about the AP survey. Among them, 2169 were eligible because they consented to participate and had an active license.

Primary survey outcomes

The study design consisted of a 9-months development phase and a 9-month implementation phase, summarized in Figure 1. The use of REDCap to distribute and administer the survey resulted in a number of efficiencies. These included (1) the ability to send survey links to participants on a large scale (at least 3500 or more participants) via email and collect their responses instantly and securely; (2) the capability to log any change made in the database to prevent accidental/erroneous changes during the study; and (3) a user-friendly interface that enabled us to export the data in the different format required for statistical analysis and so on, in various software programs, including SAS. In addition, it allowed us to manage the distribution of the survey in 3 waves. This helped avoid the possibility of a system crash or blockage, which could have occurred if it had been necessary to distribute the survey through the secure network's firewall, to the much larger group of Network practitioners, in one go.

During the launch stages of the implementation phase, a total of 3584 invitations were emailed to Network members, among 4082 network members registered on July 1, 2017. Thus, of the 2193 dental practitioners who consented to participate in this AP survey, 23 of them did not have an active license, and information was missing in 1 case. The selection process yielded 2169 eligible members consenting to the study (i.e., responders) (Figure 2). The 3 waves of the implementation phase consisted of sets of 1067, 1001,

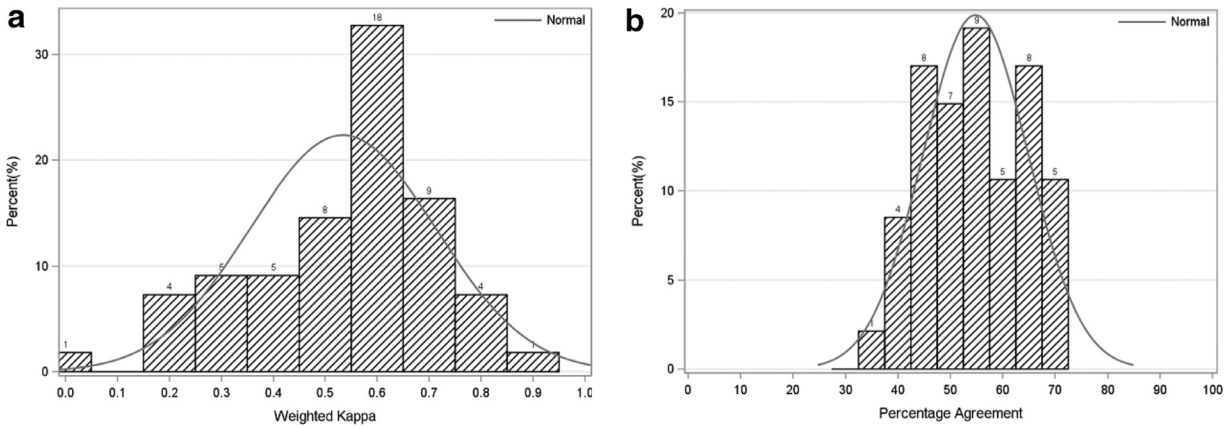

Fig. 3. Antibiotic prophylaxis (AP) survey distributions of weighted kappa and percentage of agreement. **A,** The weighted kappa distribution is slightly right-skewed. Interquartile range (IQR) for weighted kappa: 0.42−0.64. **B,** The median of percentage agreement is 55%, with an IQR of 46% to 64%.

and 1517 invitations, completed during an approximate 8.5-month period. Thirteen practitioners requested a paper-copy of the survey. Eight completed paper copy surveys were returned, and 2 "additional" online surveys were completed by practitioners who had received the paper copy.

Of the eligible practitioners who consented to participate in the survey (n = 2169), 27 provided an incomplete survey, with the total response rate being 60.5% (95% confidence interval 0.59−0.62) based on the initial 3584 Network members approached.

AP survey test−retest reliability

All 47 survey participants were invited to take the survey twice at 2-week intervals. The kappa coefficient for the 58 items of the 14 AP Survey questions ranged from 0.04 to 0.56, with a median of 0.32 and an interquartile range (IQR) of 0.20 to 0.42, indicating an overall fair to moderate strength of agreement between test and retest. Weighted kappa ranged from −0.01 to 0.89, with a median of 0.56 and IQR of 0.42 to 0.64 (Figure 3A). The median of percentage agreement was 55%, with an IQR of 46% to 64% (Figure 3B). Aggregate kappa and weighted kappa ranges (Table I) were acceptable, considering the overall number of questions and item choices per each question (i.e., 14 Likert scale AP survey questions and subquestions. excluding opening and closing survey questions). There were 2 to 7 items per question. The results suggested that higher reliability was achieved for question 1, for example, which relates to an event memorization (2 items, weighted kappa range 0.71−0.89; see Table I).

DISCUSSION

This is the first large-scale DPBRN study in which a survey instrument was designed by a multidisciplinary team to identify and better understand beliefs and behaviors of DPBRN practitioners about AP use. As noted by Funkhouser et al., surveys designed for health care professionals historically yield a lower response rate compared with those for the general public.[21] Here, we have reported a response rate of 60.5%, which is relatively high, given the complexity and controversy surrounding the AHA guidelines on AP to prevent distant site infections. Overall, the 60.5% response rate reported here compares favorably with rates reported in other surveys undertaken by the Network and is comparable with other recent dental practitioner surveys in the United States and Japan reporting response rates of 58% and 69%, respectively.[31,32]

The final questionnaire contained 12 questions focusing on AP practices and 3 companion questions, with a limited number of selection choices and with an appropriate response time range of 15 to 20 minutes based on pilot testing before launch. The pretest "think aloud" process

Table I. Kappa weighted kappa ranges, test−retest reliability for Likert scale survey questions

Survey questions	Kappa range	Weighted kappa range
1. How often do you see your infective endocarditis (IE) **OR** prosthetic knee/hip joint populations in your practice? (2 items)	0.45−0.56	0.71−0.89
2. Thinking about the 2007 American Heart Association guidelines on IE patients and **YOUR** patients who are at risk for IE, to what extent do you agree with the following statements? (7 items)	0.19−0.47	0.35−0.78
3. Thinking about the 2007 American Heart Association guidelines on prosthetic knee/hip joint and **YOUR** patients who have received a prosthetic knee/hip joint, to what extent do you agree with the following statements? (6 items)	0.17−0.39	0.24−0.62
4. How important is each of the following in **YOUR** decision to prescribe (or not prescribe) antibiotic prophylaxis?		
Part A. Official Resources (6 items)	0.10−0.53	0.45−0.75
Part B. Professional colleagues (3 items)	0.18−0.27	0.45−0.62
Part C. Personal preferences (4 items)	0.16−0.33	0.47−0.64
Part D. Patient factors (3 items)	0.24−0.49	0.29−0.73
5. How likely are you to change **YOUR** antibiotic prophylaxis prescription practices if the following situations occur?		
Part A. Official Resources (3 items)	0.09−0.32	0.24−0.64
Part B. Professional Colleagues (2 items)	0.11−0.36	0.56−0.57
Part C. Personal preferences (2 items)	0.04−0.05	0.21−0.22
Part D. Patient factors (2 items)	0.28−0.32	0.64−0.69
6. To what extent do **YOU** agree that antibiotic prophylaxis prevents infection in the following patient populations? (4 items)	0.33−0.55	0.52−0.79
7. To what extent do **YOU** agree that each of the following dental procedures put some patients at risk for IE? (5 items)	0.19−0.44	0.35−0.65
8. Do **YOU** ever prescribe, or request prescription, for antibiotic prophylaxis before invasive dental procedures in your office for patients with? (5 items)	0.30−0.52	0.25−0.41

Note: The eight 5-points Likert scale questions (and subquestions) presented, covered knowledge and perception of American Heart Association (AHA) guidelines, decision criteria to implement or change AP practices, and perception of risk/benefit ratio and associated comorbidities. Questions on eligibility/consent and survey closing questions were excluded. Item choices (not shown) were 2 to 7 per question/subquestion.

significantly reduced the cognitive demand, which, we believe, contributed to the success of this study. In addition, the use of REDCap provided significant efficiencies in the management, distribution, and analysis of the survey.

Because dentists who are DPBRM members may not be representative of all dentists practicing in the United States, by virtue of their wish to contribute to research, we compared the demographic characteristics of our DPBRN responders to those of the dentists in the 2019 American Dental Association (ADA) Health Policy Institute (HPI) database Masterfile.[33] The ADA HPI database contains the demographic details of a census of all dentists (including non-ADA members), whether practicing and not practicing in the United States, excluding dentists practicing in the U.S. territories or U.S. armed forces overseas. It provides the current age, gender, specialty, and geographic distribution of dentists nationwide.

Responder distributions were overall similar to the ADA census data with regard to gender (roughly 70% males vs 30% females). There were differences and similarities in responder age (Figure 4A) and regional location (Figure 4B). The age group distributions of AP survey responders (n = 1269) (see Figure 4A) compared with that of the 2019 ADA HPI database Masterfile[25] (sample size N = 199,486 census records from various sources), were, in decreasing order of representation, 31.6% versus 22.8% (age 55 to < 65 years; $P <$

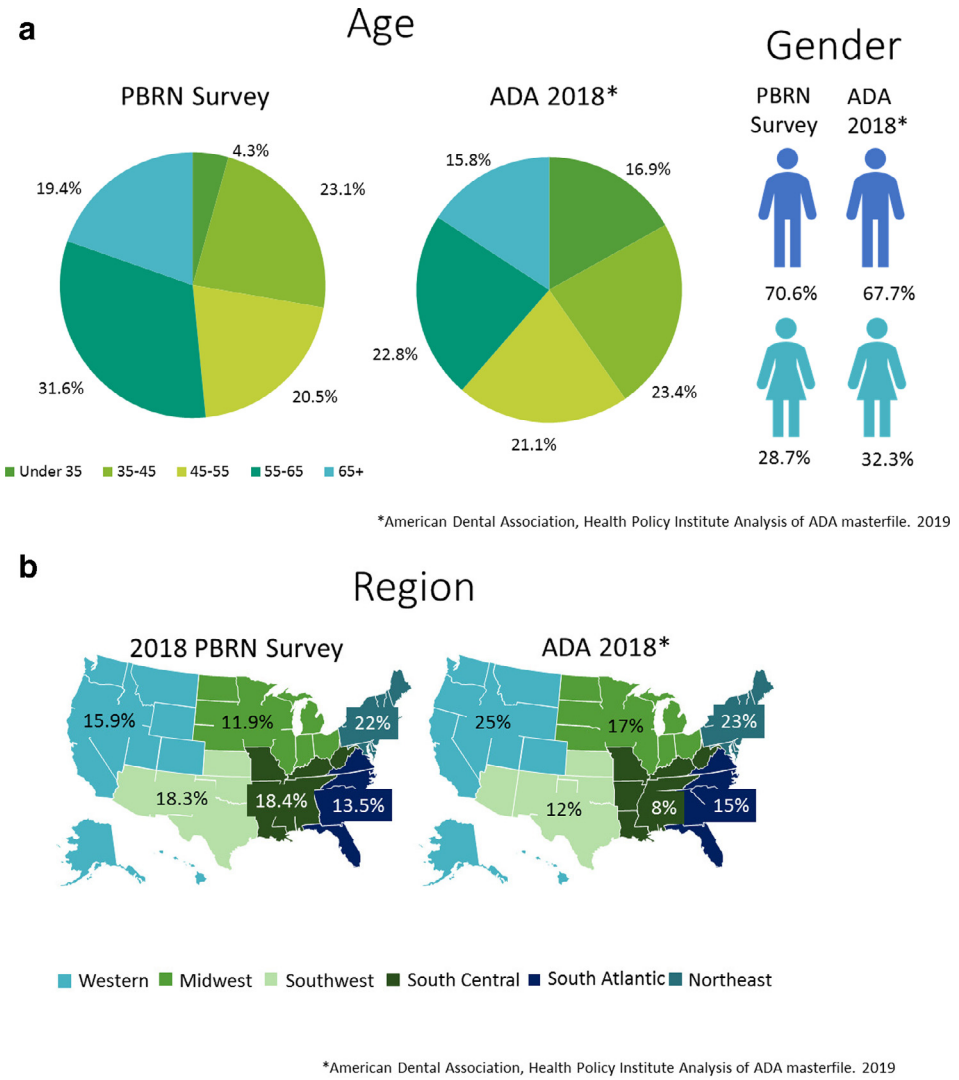

Fig. 4. Responders' distributions across age, gender, and Dental Practice-Based Research Network (DPBRN) region. Data on responder age **(A)** and **(B)** geographic distributions of the AP survey responders' proportions (i.e., eligible practicing members with an active license who consented to the study) are compared with the data in the 2018 census data of the 2019 ADA HPI Masterfile.[25] ADA records pertained to dentists with one of the following occupations: private practice (full or part time); dental school/faculty staff member; armed forces; other federal services (i.e., Veterans' Affairs, Public Health Service), state or local government employee; hospital staff dentist; graduate student/intern/resident; or other health care/dental organization staff member.

.05); 23.1% versus 23.4% (age 35 to < 45 years; $P > .05$); 20.5% versus 21.1% (age 45 to < 55; $P > .05$); 19.4% versus 15.8% (age 65+ years; $P < .05$); and 4.3% versus 16.9% (age < 35 years; $P < .05$). However, responder distributions were overall similar in ranking and order of magnitude for the age categories 35 to less than 55 years (43.6% vs 44.5%); 55 to less than 65 years (31.6% vs 22.8%); and 65+ years (19.4% vs 15.8%), respectively, besides the age category less than 35 years with significantly lower order of magnitude correspondence (4.3% vs 16.9%).

There were also disparities in geographic proportions compared with the 2019 ADA HPI data, as follows: Western (15.9% vs 25%; $P < .05$) and South Central (18.4% vs 8%; $P < .05$) regions (see Figure 4B). However, with the exception of the Western and South Central regions, differences in AP survey responders' distribution did not differ by greater than 1.5-fold as a percentage compared with the 2019 ADA HPI Masterfile census data.

In addition, the Southwest region produced the highest engagement rate, at 67% completed surveys. The South Central and South Atlantic regions were the second and third most engaged regions, with 63% and 61% response rates, respectively. The Northeast, Midwest, and Western regions all produced satisfactory response rates that were close to 60% (i.e., 58%, 58%, and 55%, respectively).

Finally, the test−retest results were acceptable, considering that the 8 main Likert scale questions (including the subquestions) represented many items (n = 58). Additionally, the AP survey was not designed for diagnostic purposes but for the collection of beliefs and knowledge about AP in dental practice, and, therefore, does not necessitate a high threshold for kappa values. Indeed, the test−retest results suggest that weighted kappa values (see Table I) may depend on the complexity of some of the domains addressed in our survey as well as the sample size of the test−retest reliability survey.

CONCLUSIONS

We established an effective survey instrument with acceptable reliability, relatively high response rate, and reasonable geographic representation to address complex domains on the topic of AP to prevent secondary infections in dental practice.

Furthermore, the consistent representation of dentists throughout the 6 regions of the United States, along with a good response rate of approximately 60% and a large sample size (2169 eligible respondents), should produce clinically relevant data. This survey instrument will be used to conduct a study of dentists' beliefs and behaviors regarding the use of AP to prevent distant site infections, which will be reported separately.

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DISCLAIMER

Opinions and assertions contained herein are those of the authors and are not to be construed as necessarily representing the views of the respective organizations or the National Institutes of Health. Informed consent was obtained from all patients who participated in this investigation after the nature of the procedures had been explained fully. An Internet site devoted to details about the nation's network is located at http://NationalDentalPBRN.org.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.oooo.2020.03.004.

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