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Virginia Commonwealth University

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Antibiotics and Antimicrobial Resistance: An Evaluation of the Knowledge, Attitude and Perception Among Dental Students and Academic Deans and Department Chairs within U.S. Dental Schools

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University

by

Magdalena S. Holz DDS
BS, Concord University 2009
DDS, West Virginia University School of Dentistry, 2014

Director: Garry L. Myers, DDS
Director, Advanced Education Program in Endodontics, Department of Endodontics
Virginia Commonwealth University School of Dentistry

Virginia Commonwealth University
Richmond, Virginia
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Abstract

Antibiotics and Antimicrobial Resistance: An Evaluation of the Knowledge, Attitude and Perception Among Dental Students and Academic Deans and Department Chairs within U.S. Dental Schools

By: Magdalena S. Holz, DDS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

Virginia Commonwealth University, 2019

Thesis Advisor: Garry Myers, DDS

Department of Endodontics

Purpose: This study aimed to survey current 3rd and 4th year dental students, academic deans, and department chairs within U.S. dental schools to analyze the level of understanding; education; guidelines; and overall awareness regarding antibiotic use within dentistry and antimicrobial resistance.

Methods: A 25-question survey intended for 3rd and 4th year dental students and a 20-question survey intended for academic deans and various department chairs of U.S dental schools were each developed utilizing REDCap. The survey invitations were sent via e-mail to the current academic dean of each U.S. dental school for distribution.

Results: There were a total of 18 respondents from the academic dean and department chair survey and 172 student respondents. Overall, 71% of students reported that they could benefit from more education regarding antibiotics. The majority of both groups agreed that dentistry

should play an important role in reducing antimicrobial resistance, but most dental students were 'not at all familiar' with the term antimicrobial stewardship and several were unsure if clinical guidelines were present at their schools.

Conclusion: Improvements to the dental educational curriculum regarding the responsible use of antibiotics, along with the implementation of stewardship programs within dentistry are strongly encouraged.

Introduction

The discovery of penicillin in 1928 by Alexander Fleming is notably one of the greatest medical advancements in history. Common illnesses such as pneumonia and tuberculosis could finally be treated effectively, a small cut was no longer fatal, and the dangers of routine surgery and childbirth were vastly reduced (1). Along with the introduction of other antibiotics in the years to follow, these “miracle drugs” quickly revolutionized healthcare. However, as antibiotic use became more prevalent over the years, so did antibiotic-resistant bacteria. We have since gained greater understanding of the infectious and inflammatory processes, the side-effects associated with antibiotics, and the emergence of resistant bacterial strains, yet the misuse of antibiotics continues to be a major concern (2–4). In fact, despite forewarnings by Fleming as early as 1945 on the dangers of over-reliance on antibiotics and of bacteria’s potential for resistance, many of history’s most important medical advances are now threatened by antimicrobial resistance (1,2).

Antimicrobial resistance develops when bacteria adapt and grow in the presence of antibiotics, and while any use of antimicrobials—regardless of how appropriate or conservative—contributes to the development of resistance, widespread and/or excessive antibiotic use can significantly increase its occurrence (1,5). Additionally, resistance among one organism can spread rapidly and unpredictably through the exchange of genetic material between different bacteria, thereby affecting the antibiotic treatment of many infections and diseases.

Resistant bacteria are often present in animals and other food products consumed by humans

and, thus, can circulate between and among human and animal populations through food and water (5).

Many of the major historic improvements in global health are now under threat because of this growing resistance to antibiotics. Microorganisms that cause common diseases and medical conditions—such as tuberculosis, HIV/AIDS, malaria, sexually transmitted diseases, urinary tract infections, pneumonia, and blood infections—have become resistant to a wide range of antimicrobial medications. Doctors are having to use more “last-resort” antibiotics that are not only more costly, with limited availability and affordability among low and middle income countries, but also are typically accompanied by more adverse side effects (1). Of further concern, the pace at which we are discovering novel antibiotics has slowed drastically, and as the use of last-resort antibiotics continues to increase, we are left with very minimal options if resistance continues to develop at the current rate (1). Within the United States alone, every year at least 2 million people become infected with antibiotic-resistant bacteria, and approximately 23,000 people die as a direct result of these infections (3,6,7). Without a change in current trends, it is estimated that a continued rise in resistance by 2050 would lead to 10 million people dying every year and would cost the world up to 100 trillion U.S. Dollars (1). Few people are aware of the threat of drug resistance, and many of those who know of this concern believe it to be a distant risk (1). However, without immediate action on a global scale, we may soon face a post-antibiotic era in which common infections could once again become lethal (5).

While some people may be at greater risk than others, no one can completely avoid the risk of antibiotic-resistant infections (7). As stated within the 2015 World Health Assembly Global Action Plan, “Antimicrobial resistance will affect everybody, regardless of where they live, their health, economic circumstances, lifestyle or behavior. It will affect sectors beyond

human health, such as animal health, agriculture, food security and economic development” (5). Therefore, we must adopt a ‘One-Health’ approach as proposed within the Global Action Plan to raise awareness and promote behavioral change through coordination among human and veterinary medicine, agriculture, environment, and consumers (5).

Healthcare workers play a vital role in preserving the power of antimicrobial medications. Antibiotics are among the most commonly prescribed medications, with dentists accounting for 10% of all outpatient antibiotic prescriptions (approximately 25.6 million) filled in the United States each year (8). However, studies show that 30%–50% of antibiotics prescribed by healthcare workers annually are either not necessary or not optimally prescribed (3,8). Therefore, it is vital that all healthcare practitioners know which clinical conditions warrant the prescription of antibiotics, properly identify the type of infection present, and remain firm despite patient pressure to prescribe antibiotics (5,9).

Progress to combat antimicrobial resistance has been slow despite previous proposals and initiatives, likely because of poor monitoring and reporting, as well as inadequate recognition by all participants of the need for action in their respective fields (5). Within dentistry, there have been several position statements and recent publications that have stressed the importance of responsible antibiotic use. Although there are relatively few indications for the use of systemic antibiotics within dentistry, inappropriate prescribing habits remain prevalent (3,8). There continues to be a great need for national prescribing guidelines that address proper management of specific dental infections as well as an investigation into the rationale for safe and effective antibiotic prescribing in dentistry. In addition, the incorporation of the proper use of antimicrobial agents and resistance as a core component in school curricula will promote a better understanding and awareness from an early age and create many advocates for change within the

profession (3,5,10). Combatting antibiotic resistance will require not only a commitment from the entire dental team but also a continued effort by all prescribers to evaluate and reassess their prescribing behaviors for appropriateness and effectiveness (3).

Bacteria play an important role in endodontic disease. As such, it would seem reasonable to assume that antibiotics would be helpful in managing endodontic symptoms; however, apart from cases of systemic involvement, antibiotics are not effective in many clinical scenarios associated with endodontic signs and symptoms (11). Irreversible pulpitis, for example, is considered to be an immune system-mediated event. It is often not a result of a bacterial infection of the pulp, but rather of inflammatory mediators released during an inflammatory response within the pulp (10). Therefore, antibiotics would have no benefit. To be therapeutically effective, antibiotics rely on achieving at least a minimal inhibitory concentration (MIC) of the drug at the site of infection. For more advanced endodontic infections, the dental pulp tissue is no longer vascularized, and orally-administered antibiotics are unable to reach the site of infection within the canal spaces. In cases of an acute apical abscess, the presence of pus further limits vascular supply and often contains cellular debris and proteins that make these drugs significantly less effective within bone in the absence of adequate drainage. This further supports the rationale that antibiotics should only be used as adjuvant therapies in cases with evidence of systemic involvement (e.g., fever, malaise, cellulitis, and lymphadenopathies) following adequate endodontic disinfection of the root canal system and drainage if swelling is present (12).

Apart from the previously discussed risk of antimicrobial resistance, antibiotics are not the harmless drugs that many patients and even some clinicians perceive them to be. An estimated 1 in every 5 emergency department visits associated with adverse drug events in the

United States is antibiotic related (3). Antibiotics are also a main cause of Clostridium difficile infections (C. difficile), a potentially deadly form of diarrheal disease associated with considerable costs to patients and the healthcare system (3). Apart from the risk of C. difficile, other commonly prescribed antibiotics have a side effect profile that ranges from gastrointestinal disturbances and hepatic toxicity to severe anaphylactic allergic reactions (12).

In the event that antibiotics are necessary, practitioners should use the shortest effective course duration, minimize the use of broad-spectrum antibiotics, and monitor the patient closely (12). Most practitioners typically prescribe antibiotics in courses of 3 to 7 days; however, some evidence suggests that shorter courses of 2 to 3 days may be used as adjuvant therapies with successful results (11,12,13). Ideally, patients should be evaluated daily and the antibiotic therapy terminated once the infection appears to be resolving (8). This increased evaluation may be beneficial in the prevention of additional antimicrobial resistance, as therapies lasting 7 days with amoxicillin have been shown to increase the population of resistant strains (12).

Choosing when to prescribe antibiotics within dentistry can be a difficult and often conflicting decision. Healthcare providers want to deliver optimal therapy to their current patients. However, there is also a responsibility to future patients and to public health in sustaining the efficiency of antibiotics and minimizing antibiotic resistance (15). Studies in which investigators assessed the knowledge, attitudes, and behaviors regarding antibiotic use among physicians indicate the following motivating factors that result in overprescribing: patient demands and expectations; providers' perceptions related to patient expectations; fear of litigation; and diagnostic uncertainty. One would assume that it is these similar pressures that affect prescribing in dentistry as well (1). The issue of patient perception and demand is further complicated by the fact that many patients perceive improvement in their condition after taking

antibiotics, at least in part due to a strong placebo effect that antibiotics may have (12). Germack et al. found that 36.89% of respondents reported prescribing antibiotics that were not necessary, most commonly because of patient expectations or when the patient or clinician had travel plans. Though not statistically significant, this was a positive trend compared to previous surveys from 1994 and 1999 that reported that antibiotics were incorrectly prescribed as much as 67% of the time (8,16,17). Still yet, there continues to be much room for improvement.

The preservation of antibiotics for future generations through ‘sustainable use’ should be at the forefront of public policy and healthcare as a whole, to include the field of dentistry. In order to maximize the current and future wellbeing of our population, optimal prescribing and consumption of these drugs is required. The current demand for both ‘appropriate’ and ‘inappropriate’ antibiotics must be lowered through infection prevention and control, increased public awareness, and improved treatment guidelines among the professions (18). Recently, the term “stewardship” has been frequently discussed and applied to the matter of antibiotic use and prescribing. According to the Centers for Disease Control and Prevention, “antibiotic stewardship is the effort to measure antibiotic prescribing; to improve antibiotic prescribing by clinicians and use by patients so that antibiotics are only prescribed and used when needed; to minimize misdiagnoses or delayed diagnoses leading to underuse of antibiotics; and to ensure that the right drug, dose, and duration are selected when an antibiotic is needed (19).” Improved education regarding the responsible use of antibiotics, along with the implementation of stewardship or monitoring programs, will help practitioners identify the circumstances when antibiotics are indicated, choose the right antibiotic, and prescribe it at the correct dosage and duration. In the meantime, the *routine* use of antibiotics in conjunction with endodontic

treatment should be discouraged, as it does not abide by the principles of an evidence-based practice.

In order to best determine our future direction, we need to thoroughly evaluate our current standing. With the ever-growing threat of antimicrobial resistance and the necessity to develop antibiotic stewardship programs, this subject has been more thoroughly assessed within medical and pharmacy schools over the past few years. In fact, it appears as though many early stewardship pilot programs are already being implemented within various hospital settings (20,21). Within dentistry, there is very little existing data available that assesses the educational curricula and student perception regarding antibiotics, and while it has been clearly stated that antibiotic stewardship programs are needed in the future, to our knowledge, little to none currently exist within dentistry in the United States. Additionally, little is still known about the overall quality and content of the medical and dental curricula on the principles of antimicrobial stewardship and resistance or antibiotic prescribing practices in general (22). Within medicine, there have been several surveys that have concluded that students would like greater instruction on the issue of antibiotic use (23,24). It is assumed that this would also be true among dental students, but no current studies appear to have specifically evaluated this to date within dentistry.

Therefore, the purpose of this study was to conduct a survey among current 3rd and 4th year dental students, as well as the academic deans and department chairs of U.S. dental schools to analyze the level of understanding and preparedness; education and clinical teachings; guidelines; and overall outlook and awareness regarding antibiotic use within dentistry and the threat of antimicrobial resistance. Only those dental students in their 3rd and 4th years of training were selected as the intended student audience for this survey, as they had, at this point, typically received the majority of their basic science and dental didactic courses and had entered into

clinical practice. Additionally, academic deans and department chairs were chosen to serve as a comparison and to gain further insight into the administrative sector regarding this subject.

Overall, this assessment aimed to provide understanding into the most effective educational approaches surrounding this topic, evaluate the level of preparedness among students, and assess the overall usefulness of the current education to better direct our focus for change during this time of increasing need for antimicrobial stewardship programs and awareness within dentistry.

It is also our hope that the findings of this study will set the stage for the development of antimicrobial stewardship guidelines within dental software programs in the educational and private practice sectors and encourage additional in-depth surveys and research to be supported and/or performed by more influential and wide-reaching dental associations in the future.

Methods

This study was reviewed and declared exempt by the Virginia Commonwealth University Institutional Review Board [Reference #HM20012221]. Several questions were based on previous medical surveys of similar aim and topic, and a pilot questionnaire was distributed to endodontic faculty and dental researchers in the School of Dentistry at Virginia Commonwealth University for review of appropriateness and clarity. After which, two surveys were finalized: a 25-question survey intended for 3rd and 4th year dental students, and a 20-question survey intended for academic deans and the various department chairs of U.S dental schools. Survey questions and study data were collected and managed using REDCap electronic data capture tools hosted at Virginia Commonwealth University. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources (25). Wherever possible, the survey questions were formatted as drop-down or selection options. E-mail addresses of the current academic dean of each U.S. dental school were obtained, and two separate invitations to participate in the study were e-mailed to each of the 66 academic deans in April 2018. The first survey invitation was intended for distribution to dental students,

with a request for the academic dean within their respective school to distribute the survey to 3rd and 4th year dental students. The second survey was intended for completion by the academic dean and department chairs of U.S. dental schools, with a request to the academic deans for voluntary self-participation and further distribution to each of the department chairs within their respective dental school that typically had antibiotics being prescribed within their department. Both invitations included instructions and details regarding the study's purpose and a link to the specific survey intended for that respondent group. E-mail invitations were sent three times, 3 weeks apart, giving respondents a total of 9 weeks to respond. The dental academic faculty and dental students who participated did so voluntarily, anonymously and without compensation.

Demographic characteristics for both deans and students were presented in tables using means (with standard deviations) and proportions (with percentages) where appropriate; this included age, gender, and region of school. Dean-specific characteristics also included which faculty or administrative positions were currently held. Likewise, student-specific characteristics included current year in dental school and plans after graduation. The responses of 3rd and 4th year dental students were directly compared for a variety of survey questions. For continuous responses (i.e. confidence levels; range: (0–100)), Student's t-Tests were performed to assess differences in mean response values among 3rd and 4th year students. For categorical responses, Fisher's Exact Tests were performed to test the association between survey question and program year. Following inter-student comparisons, we also compared the responses between deans and students for a series of different survey questions. For categorical responses, we used Fisher's Exact Tests to assess associations between survey question and dental school affiliation. For two survey questions included in the analysis, students and deans were allowed to choose at most 3 different responses. When evaluating these results, we used proportion tests to assess

whether the proportion of responses was the same between deans and students. The alpha level of significance was set to 0.05 for all significance tests. Furthermore, all statistical analyses were performed in R version 3.5.1.

Results

There were a total of 18 respondents from the survey intended for deans and department chairs of dental schools. From Table 1 we see that the average age was 59.7 years (SD=10.1) and a majority of the respondents were male (56%). Of the faculty that responded to the survey, 8 reported as being a department chair (44%), 3 reported as an academic dean (17%), while the remaining responded by choosing the “Other” category (39%). The survey had respondents from all four regions of the country, with most being located in the south (39%). Please note, this group of respondents will be referred to as ‘deans’ or ‘academic faculty’ for future notation here after.

Table 1: Demographic characteristics for deans and department chairs of dental schools throughout the country that responded to the survey.

Variable	N = 18
Age (sd)	59.7 (10.1)
Gender	
Female	7 (39%)
Male	10 (56%)
Prefer not to answer	1 (5%)
Position	
Academic Dean	3 (17%)
Department Chair	8 (44%)
Other	7 (39%)
Region of School	
Midwest	5 (28%)
Northeast	2 (11%)
South	7 (39%)
West	4 (22%)

A total of 172 3rd and 4th year dental students responded to the survey. From Table 2, we see that the total number of students in each year was evenly split, with 86 students within each group. The average age of the students was 27.6 years (SD=4.6), and a majority of dental students identified themselves as female (60%). Similar to the deans, most dental students were recorded as being from dental schools within the southern region (36%). When asked what their plans were following graduation, most students responded with the intent to either go into private practice (44%) or attend a residency program (41%). From Table 3, of the 70 students that expressed their preference to attend a residency, most preferred General Practice residency programs (33%).

Table 2: Demographic characteristics for dental students throughout the country that responded to the survey.

Characteristic	N = 172
Current Year of Study	
3rd Year	86 (50%)
4th Year	86 (50%)
Age (SD)	27.6 (4.6)
Gender	
Female	104 (60%)
Male	68 (40%)
Region of School	
Midwest	29 (17%)
Northeast	33 (20%)
South	62 (36%)
West	48 (27%)
Plans following graduation	
Private Practice	75 (44%)
Academia	2 (1%)
Public Practice	6 (3%)
Corporate Practice	15 (9%)
Residency	70 (41%)
Other	4 (2%)

Table 3: Frequencies of the preferred residency programs for dental students in the survey.

Preferred Residency Program	N = 70
Advanced Ed in Gen Dentistry	13 (19%)
Endodontics	3 (4%)
General Practice Residency	23 (33%)
Oral & Maxillofacial Surgery	8 (11%)
Orthodontics	9 (13%)
Pediatric Dentistry	7 (10%)
Periodontics	4 (6%)
Prosthodontics	3 (4%)

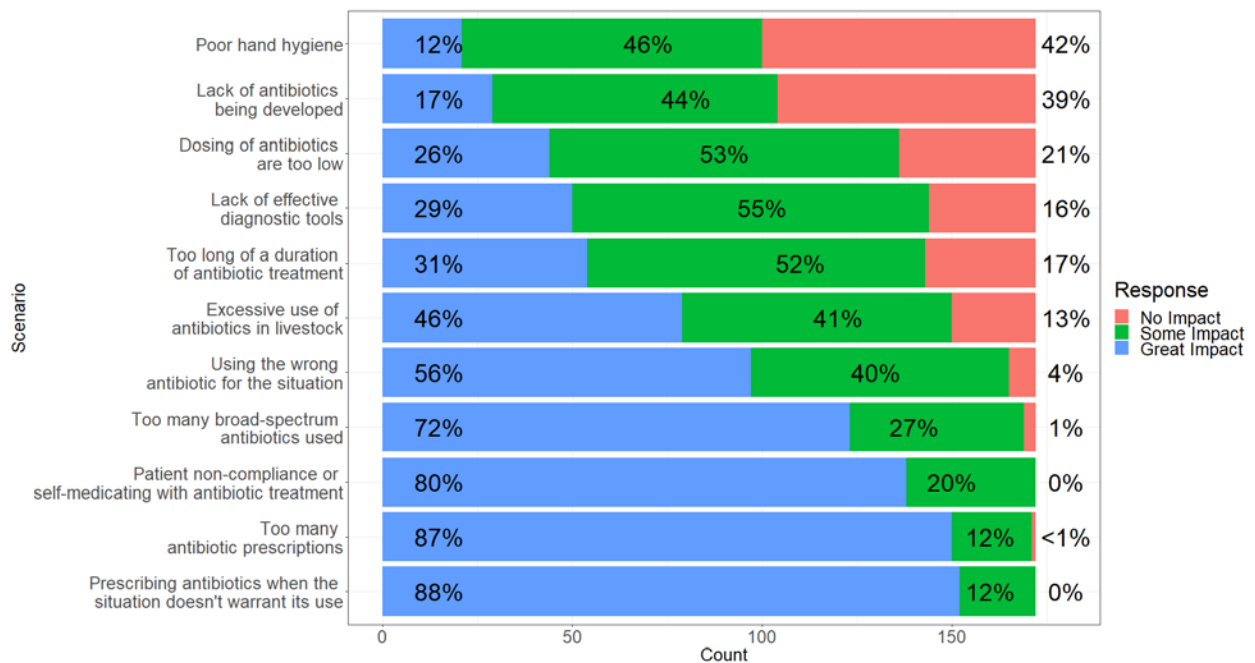
When dental students were asked about their level of confidence (on a 0–100 scale) regarding a series of scenarios involving prescribing antibiotics, students in either their 3rd or 4th year were most confident given the scenario of “handling a patient who demands antibiotic therapy when it is not indicated” ($p = 0.944$). Likewise, from Table 4, the greatest disparity in mean confidence between 3rd and 4th year dental students was in regards to the scenario of “making an accurate diagnosis of infection” ($p = 0.003$). Both 3rd and 4th year dental students were least confident when it came to “choosing the correct dose and interval of therapy”, with mean confidence of 59.3 and 66.4 respectively ($p = 0.056$). Both 3rd and 4th year students responded largely the same with regards to the department/courses that they felt they gained the majority of their decision-making skills and knowledge surrounding antibiotic prescribing practices. Only the department of Endodontics was significantly associated with student year, with a greater proportion of 4th year students feeling as though this department was key in their knowledge of antibiotics.

Table 4: Comparison of responses between 3rd and 4th year dental students with regard to specific questions and scenarios from the survey using means and proportions. P-values from significance tests in the form of Student's t-Test and Fisher's Exact Tests were reported where appropriate.

Survey Question	Level	Year of Dentistry		P Value
		3rd (N=86)	4th (N=86)	
With your current level of understanding, how confident would you feel in the following scenarios when prescribing an antibiotic by yourself? (0-100)	Making an accurate diagnosis of infection	71.2 (21.5)	79.8 (15.3)	0.003
	Choosing the correct antibiotic	64.0 (23.0)	71.1 (18.5)	0.029
	Choosing the correct dose and interval of therapy	59.3 (26.2)	66.4 (21.8)	0.056
	Choosing the correct duration of the antibiotic	61.7 (25.1)	69.1 (23.4)	0.047
	Handling a patient who demands antibiotic therapy when it is not indic	77.0 (20.6)	77.2 (22.9)	0.944
Which department/courses do you feel you have gained the majority of your decision-making skills and knowledge regarding antibiotic prescribing practices?	Community Dentistry	3 (3%)	10 (12%)	0.08
	Endodontics	20 (23%)	40 (47%)	0.002
	Epidemiology	2 (2%)	1 (1%)	>0.999
	Microbiology	14 (16%)	12 (14%)	0.832
	Periodontics	14 (16%)	17 (20%)	0.692
	Pharmacology	46 (53%)	43 (50%)	0.76
	Oral Diagnosis/Medicine	28 (33%)	24 (28%)	0.619
How many hours of training in principles of antibiotic use do you think you have received to date in your dental education?	Oral Surgery	60 (70%)	66 (77%)	0.389
	Other	15 (17%)	7 (8%)	0.108
	0-10	27 (31%)	22 (26%)	0.752
	11-20	36 (42%)	34 (40%)	
	21-40	16 (18%)	23 (27%)	
What kind of teaching format has been used during your education on antibiotics?	41-60	5 (6%)	5 (6%)	
	61+	2 (2%)	2 (2%)	
	Lectures	81 (94%)	86 (100%)	0.059
	Clinical Vignettes/Case Discussions	46 (53%)	49 (57%)	0.759
	E-learning	12 (14%)	16 (19%)	0.536
Who/what has had the greatest impact on your decision of when and how to prescribe antibiotics?	Web-based learning platform	10 (12%)	11 (13%)	>0.999
	Direct patient care	61 (71%)	69 (80%)	0.214
What percentage of antibiotic prescriptions within dentistry do you think are estimated to be unnecessary or inappropriate?	Other	5 (6%)	1 (1%)	0.211
	Full-time faculty in clinic	70 (81%)	79 (92%)	0.071
	Part-time faculty in clinic	33 (38%)	37 (43%)	0.642
	Student peers	9 (11%)	7 (8%)	0.759
	Didactic courses	39 (45%)	33 (38%)	0.4397
	Personal experience	19 (22%)	16 (19%)	0.705
Dentistry should play an important role in reducing antimicrobial resistance?	Personal research/investigation	8 (10%)	9 (11%)	>0.999
	Other	2 (2%)	2 (2%)	>0.999
	<1%	1 (1%)	1 (1%)	0.873
	1-20%	21 (24%)	26 (27%)	
	21-40%	31 (36%)	29 (30%)	
How interested are you in playing a role in this improvement through better self-monitoring and antibiotic stewardship (1-100)?	41-60%	28 (33%)	30 (31%)	
	61-80%	5 (6%)	9 (10%)	
	81-100%	0 (0%)	1 (1%)	
	Strongly Disagree	0 (0%)	0 (0%)	0.687
	Disagree	0 (0%)	0 (0%)	
How interested are you in playing a role in this improvement through better self-monitoring and antibiotic stewardship (1-100)?	Neutral	3 (3%)	4 (5%)	
	Agree	39 (45%)	44 (51%)	
	Strongly Agree	44 (51%)	38 (44%)	
	Mean (SD)	76.9 (20.6)	80.4 (19.2)	0.263

The results of dental students' responses to the most important contributors to resistance of antibiotics are presented in Figure 1. Of the list of 11 different scenarios, the top three strongest contributors to antibiotic resistance, with 88%, 87%, and 80% of responders saying they had a "Great Impact", were "prescribing antibiotics when the situation doesn't warrant its use", "too many antibiotic prescriptions", and "patient non-compliance or self-medicating with antibiotic treatment", respectively. Conversely, students found "poor hand hygiene", "lack of antibiotics being developed", and "dosing of antibiotics are too low" as being the lowest contributors to antibiotic resistance, with 42%, 39%, and 21% of responders reporting that they had "No Impact", respectively.

Figure 1: A list of 11 scenarios where antibiotic resistance can occur. Students labeled the scenarios as having "No Impact", "Some Impact", or "Great Impact".



Dean and student responses were compared for the survey questions presented in Table 5. The responses for deans and students were similar for all questions except numbers 2, 4 and 5. For those questions, there was a significant association between the responses of students and deans at the 0.05 level of significance. For Question 2, a larger percentage (92%) of students felt that they received, at most, either between 0–10 or 21–40 hours of antibiotic training in 4 years of schooling compared to deans and department chairs (84%). Likewise, for Question 4, regarding the percentage of unnecessary or inappropriate antibiotic prescribing, a larger proportion of deans responded at the extremes (either <1% or 81–100%) compared to students. Lastly, for Question 5, a greater proportion of deans did not think students could benefit from more education on antibiotic selection compared to students.

Table 5: Comparisons of responses between students and deans with regards to specific questions from the survey. P-values from Fisher's Exact Tests were reported.

Question	Response	Students (N=172)	Deans (N=18)	P-Value
1. How would you rate the education regarding appropriate use of antibiotics in the dental school curriculum?	Very useful	41 (24%)	9 (50%)	0.213
	Useful	94 (55%)	8 (44%)	
	Neutral	27 (16%)	1 (6%)	
	Not useful	9 (5%)	0 (0%)	
	Not at all useful	1 (<1%)	0 (0%)	
2. How many hours of training in principles and indications of antibiotic use do the dental students receive during their 4 years of study?	0-10	49 (28%)	3 (17%)	0.003
	11-20	70 (41%)	10 (56%)	
	21-40	39 (23%)	2 (11%)	
	41-60	10 (6%)	0 (0%)	
	60+	4 (2%)	0 (0%)	
	Unknown	0 (0%)	3 (17%)	
3. Do you feel that the field of dentistry should play an important role in reducing antimicrobial resistance?	Strongly Agree	82 (48%)	12 (67%)	0.318
	Agree	83 (48%)	6 (33%)	
	Neutral	7 (4%)	0 (0%)	
	Disagree	0 (0%)	0 (0%)	
	Strongly Disagree	0 (0%)	0 (0%)	
4. What percentage of antibiotic prescriptions within dentistry do you think are estimated to be unnecessary or inappropriate?	<1%	2 (1%)	2 (11%)	0.005
	1-20%	37 (22%)	1 (6%)	
	21-40%	60 (35%)	7 (39%)	
	41-60%	58 (34%)	6 (33%)	
	61-80%	14 (8%)	0 (0%)	
	81-100%	1 (<1%)	2 (11%)	
5. Do you think students could benefit from more education on antibiotic selection and indications at your dental school?	Yes	122 (71%)	9 (50%)	0.039
	No	3 (2%)	2 (11%)	
	Receiving adequate training	47 (27%)	7 (39%)	

Table 6 presents the results of the surveys between students and deans when asked which teaching format(s) were most helpful in the education and understanding related to antibiotics. It was found that both students and deans felt that direct patient care was most helpful (80% and 94% respectively). The pattern of responses was similar for the rest of the categories with none being significantly different between students and deans. Furthermore, when asked which department currently incorporates antibiotics into the curriculum, results from Table 7 indicated

that most students responded with Oral Surgery (73%). This contrasted with the deans, which indicated that the Pharmacology department was where a large portion of the instruction consistently occurred (100%). Additionally, there were also significant discrepancies between deans and students within the departments of Endodontics, Periodontics, Microbiology, and as discussed previously, Pharmacology. For those departments, results indicated that a greater proportion of deans than students believed that these departments more readily incorporated antibiotics within their curriculum.

Table 6: Comparison of responses for students and deans regarding what resource(s) they thought were most helpful in the education and understanding related to antibiotics. Each group was asked to choose at most three. P-values from resource-specific tests of proportions were reported.

Format	Students (N=172)	Deans (N=18)	P - Value
Lectures	96 (56%)	10 (56%)	0.62
Clinical Vignettes/Case Discussions	80 (47%)	12 (67%)	0.216
E-learning	14 (8%)	3 (17%)	0.386
Web-based learning platform	8 (5%)	1 (6%)	>0.999
Direct patient care	137 (80%)	17 (94%)	0.475
Specialty rotations	48 (28%)	7 (39%)	0.597
External rotations	26 (15%)	1 (6%)	0.317
Other	2 (1%)	0 (0%)	NA

Table 7: Comparison of responses for students and deans/department chairs regarding which department currently incorporates antibiotics into the curriculum. Each group was asked to choose at most three. P-values from resource-specific tests of proportions were reported.

Department	Students (N=172)	Deans (N=18)	P - Value
Community Dentistry	13 (8%)	1 (5%)	>0.999
Endodontics	60 (35%)	15 (83%)	<0.001
Epidemiology	3 (2%)	2 (11%)	0.072
Microbiology	26 (15%)	11 (61%)	<0.001
Periodontics	31 (18%)	15 (83%)	<0.001
Pharmacology	89 (52%)	18 (100%)	<0.001
Oral Surgery	126 (73%)	16 (89%)	0.252
Other	74 (43%)	4 (22%)	0.129

Discussion

To our knowledge, this was the first study evaluating the perceived effectiveness of the current curricula among U.S. dental schools, as well as the perception, attitude and beliefs regarding antibiotic use and antimicrobial resistance among current 3rd and 4th year dental students. To a lesser degree, an effort was made to similarly assess the opinions of the academic deans and department chairs of U.S. dental schools and compare their views and responses to those of dental students. Several comparable studies have been performed within medical and pharmacy schools over the last several years regarding antimicrobials; however, this appears to have been slow reaching into the field of dentistry. One factor that may have contributed to the limited number of studies in this area within dental schools is the difficulty in obtaining direct contact information for currently enrolled dental students. To attempt to overcome this obstacle, we relied on the academic dean of each dental school to voluntarily distribute the survey to the 3rd and 4th year dental students and department chairs within their institution. Unfortunately, this survey distribution design did not fully allow for the overall response rate to be clearly determined for either respondent group, as it was anonymous as to which academic deans chose to participate in this request, as well as how many students and department chairs directly received the survey.

Among the 172 student respondents that met the inclusion criteria of being in their 3rd or 4th year of dental school, there appeared to be an equal distribution among student's year of study, a greater number of female respondents, and representatives from all four regions. With 44% of student respondents planning to enter private practice following graduation and 41% of students planning to attend a residency program, these results appeared to be consistent with those findings from the most recent surveys completed by the American Dental Education Association of dental school seniors, providing a variation of external validity to the sample population (26). Although the ADEA survey cannot serve as a direct comparison, it appeared to be the only other available survey of students within U.S. dental schools and provided valuable data for comparison and future direction. Among the 18 total faculty respondents, 39% reported as "Other" (as opposed to department chair or academic dean) with respondents being from all 4 regions of the country. It is unclear as to what academic position or role many of these "Other" respondents most clearly identified with, as few listed additional information within the text box.

Dental students and deans selected contrasting answers to several of the survey questions. Notably, it was found upon comparison that responses differed regarding the total hours of training in antibiotics thought to be received by students, the estimated percentage of inappropriate antibiotic prescribing within dentistry, and of greatest significance to this study, if students could benefit from more education on antibiotic selection and indications. In terms of additional education, a greater percentage of faculty respondents did not feel that students could benefit from more education regarding antibiotic selection compared to that of students. This suggested that faculty respondents may have had a false sense of the effectiveness of the current education regarding antibiotics or were unaware of the exact amount and quality of training that the students currently received among the various disciplines. With 71% of dental students

reporting that they could benefit from additional education regarding antibiotics, this was also found to be somewhat inconsistent with results obtained from the ADEA Survey of Dental Seniors, 2017 Graduating Class Tables Report which found that 59.7% felt that they were 'prepared' and 18.2% felt that they were 'well-prepared' for practice in the area of "Therapeutics and Prescription Writing", for a total of 77.8% combined (26). As antibiotic use was not a selected area listed for evaluation within the ADEA survey, this was the most similar area found for comparison; however, it would be of great benefit to incorporate the topic of antibiotics and antimicrobial resistance into future ADEA senior surveys to reach a larger number of students and further assess changes in this area as they are implemented within the curriculum. As it is clear within this study that additional education would be well received and was requested among students, we must next evaluate where students feel they are receiving the majority of their education and which formats are found to be most helpful. As reported by dental students, it appears as though lectures were among the most widely used teaching formats currently utilized in the dental curriculum regarding antibiotics, followed by direct patient care, and clinical vignettes. However, both dental students and deans agreed that direct patient care was the most helpful teaching format for this topic of study. With direct patient care appearing to be the most beneficial format, it is important to understand what or who has had the greatest impact on the student's decisions of when and how to prescribe antibiotics. According to dental students, the greatest influence regarding their clinical decision making on antibiotic prescribing was provided by working with full-time faculty in clinic. Therefore, it is of utmost importance that all full-time and part-time faculty continually stay up-to-date with the most current prescribing guidelines within each facet of dentistry and encourage the prescription of antibiotics only when appropriate and supported by an evidence-based practice philosophy. Although the previously discussed

findings regarding the use of antibiotics among endodontists, as well as other studies evaluating the appropriateness of our prescribing habits within dentistry, cannot be directly applied to academic faculty, one would assume that similar patterns would be found (8,16). With even slight enhancements to the educational curriculum and clinical teachings regarding prudent antibiotic use, there is a great opportunity to lower the number of inappropriate antibiotics being prescribed in the future by correctly educating our current students at all levels of educational influence. A previous review article evaluating the educational effectiveness regarding antibiotic use found that it is during undergraduate medical training that the knowledge, attitudes and behaviors are shaped the most. As a result, it is suggested that curricula on this topic should be developed and incorporated as soon as possible within their undergraduate dental education (15).

In terms of which courses and/or departments provided the majority of the student's education/knowledge pertaining to antibiotics, 73% of students responded with Oral Surgery, followed by Pharmacology (52%) and Endodontics (35%). Within most facets of dentistry, there are very specific indications for when antibiotics are recommended, as well as which antibiotics should be selected for use. It is important that each department play a role in the dental curriculum pertaining to antibiotics and provide clear guidelines specific to their specialty. When students were asked if established clinical guidelines existed among the various disciplines of their dental school, Oral Surgery was found to have the greatest number of positive responses among dental students, followed by General Practice and Endodontics. Unfortunately, there was also a large percentage of students that responded, "I don't know" to this same question. Likewise, when a similar question was asked of the academic deans and department chairs, 6 of the 18 total faculty responded "No" when asked if any disciplines/departments within their dental school had established clinical guidelines for antibiotic prescribing. Comparable results,

however, were found in terms of which disciplines/departments were thought to have clinical guidelines in place, with Endodontics, General Practice, Institution-Wide and Oral Surgery being the most highly chosen responses. Nonetheless, if clinical prescribing guidelines do currently exist among the various disciplines within their institutions, they need to be more readily apparent to both faculty and students and more diligently taught to dental students at all levels.

Dental students were also presented with several scenarios regarding their level of confidence involving antibiotic prescribing. Both 3rd and 4th year students appeared to be most confident with “handling a patient who demands antibiotic therapy when it is not indicated”, which can be a challenge at any level of practice experience but tends to be much more manageable when the specific diagnosis and antibiotic guidelines are understood. In contrast, both groups of students were least confident in “choosing the correct dose and interval of therapy”, followed by “choosing the correct duration of the antibiotic”. With several new studies supporting shorter durations of therapy, this is an area that both students and practicing clinicians could benefit greatly from additional education if this recommendation is further supported. Among 3rd and 4th year dental students, the greatest disparity in mean confidence was in regard to the scenario of “making an accurate diagnosis of infection” ($p = 0.003$), with 3rd year students appearing to be significantly less confident in this specific area.

Similar comparisons were made among responses to several other questions. Both 3rd and 4th year students were found to have responded largely the same with regards to where they felt they gained the majority of their decision-making skills and knowledge regarding antibiotic prescribing practices, hours of training, most widely used teaching formats, etc. It was found that only the training received from the department of endodontics was significantly associated with

student year, with a greater proportion of 4th year students believing the department played a key role in their knowledge of antibiotics.

The majority of dental students appeared to be aware that antimicrobial resistance is a national problem, and they felt that “prescribing antibiotics when the situation didn’t warrant its use”, “too many antibiotic prescriptions”, and “patient non-compliance or self-medicating with antibiotic treatment” were the main contributors to antibiotic resistance. Whereas they believed “poor hand hygiene”, “lack of antibiotics being developed”, “dosing of antibiotics being too low”, “lack of effective diagnostic tools”, and “too long of a duration of antibiotic treatment” to have the lowest degree of impact. While all of these have been found to have some impact on the development of antimicrobial resistance, these initial three scenarios are comparable concerns to those found in similar surveys carried out within medical schools that evaluated antimicrobial stewardship and the knowledge, attitudes and beliefs among medical students (27). However, it may suggest that students in general could benefit from a more well-rounded curriculum regarding antimicrobial resistance, as a “lack of antibiotics being developed”, in particular, has been repeatedly mentioned as one of the major concerns related to resistance in the recent years (5,7). Students also were found to be aware that not all antibiotic prescribing is appropriate, with 35% and 34% of students, respectively, estimating that 21–40% and 41–60% of prescriptions within dentistry are unnecessary or inappropriate. With these percentages being within range to those found in various studies providing estimates of inappropriate antibiotic prescribing by dentists, it should be no surprise that dentistry has a role to play in reducing antimicrobial resistance with more judicious antibiotic prescribing practices. Current dental students have a responsibility as well, and almost all students and faculty tended to agree or strongly agree with this belief. Yet, with 58.1% and 22.1% of dental students being “not at all familiar” and “not

familiar” with the term antimicrobial stewardship, we still have a long way to go to raise awareness and develop stewardship programs within dentistry in the United States. In comparison, a survey exploring the antimicrobial stewardship principles that were included in the curriculum of medicine, pharmacy, nursing, dentistry, and veterinary medicine universities in the United Kingdom found that 100% of dental universities included in the survey incorporated antimicrobial stewardship in their curricula, despite a much lesser number for those that included all recommended principles (28). Fortunately, the majority of dental students within our survey reported that they were interested in working to actively improve antimicrobial resistance through better self-monitoring and antibiotic stewardship programs despite their apparent lack of knowledge as to what this entails. They also appeared to understand that if left unmonitored, the consequences of antimicrobial resistance will affect their future work within dentistry, with “increased morbidity due to untreatable bacterial infections” and “increased spread of communicable diseases due to untreatable infections” being the greatest problems that they will face within healthcare.

Several limitations existed within this study. Although we were unable to accurately calculate a response rate based on the distribution design of this survey, with an estimated number of combined 3rd and 4th year dental students of approximately 8,000–10,000 among the current U.S. dental schools, our number of student respondents would account for around 1–2% of total dental students. However, it is of note that surveys of this nature typically have a very low response rate in general regardless of the distribution method. Similarly, among academic deans and department chairs, the total number of respondents was only 18, with 7 of those participants categorizing themselves as “Other”, and as email forwarding was required for further distribution to all participants, which recipients received the survey was ultimately up to

the discretion of the academic dean for both surveys. In this way, the survey may have been biased on the level of distribution as well as on the level of participants, as we may have received responses from more highly motivated and knowledgeable students and/or students or faculty from dental schools that are already actively aware of antimicrobial resistance and aiming to raise further awareness or implement stewardship programs within their institutions. Another limitation within this study was the time of the academic year that it was initially distributed. The survey was first sent for distribution in April 2018 in order for the current 3rd and 4th year dental students to be near the end of their academic calendar so as to have ideally received the greatest amount of education at that point, with email reminders sent to each academic dean twice to follow. This is also the time of the year that tends to be very demanding in terms of board examinations, requirements, and graduation for 4th year students and nearing semester finals for all students and faculty. As a result, this could have somewhat impacted the response rate and willingness to participate at the level of the academic dean, faculty and students. Additionally, in order to address and evaluate many various aspects of the topic, both surveys were fairly lengthy. This also could have detracted from the total number of participants and survey completions. As a result of these limitations, findings of this survey may not be generalizable to the entire dental student or academic faculty population, but rather are a representation only.

Additional research is still needed to determine which teaching formats and specific content should be utilized in order to provide future practitioners with the information needed to use antibiotics adequately within dentistry. This will be simplified as more clearly defined prescribing guidelines are made available among each specialty, as well as among dental organizations and associations. In terms of ways to best incorporate antibiotic stewardship programs into dentistry, it may be beneficial to first introduce this in some variation within the

dental software systems used within dental schools. With over 88% of North American dental schools currently utilizing axiUm dental software, this could provide a platform for a potential pilot program for antibiotic stewardship within the software's prescription section (29). If each of these components are incorporated early within the dental curriculum, it could make future prescribers more open-minded for further education on antibiotic prescribing and antimicrobial resistance, as well as to changes to the antibiotic stewardship protocols as further advancements are made. Additionally, students are in an environment that is conducive to providing feedback and suggestions to simplify use and also allow for research and tracking to easily be performed during the initial development and application phase. A solution that has also been proposed within medical schools to address the gaps in knowledge regarding antibiotic prescribing is the incorporation of antimicrobial education as a requirement for individual revalidation and accreditation of schools (30). It is likely that something similar may be incorporated into the dental accreditation guidelines in the near future as well. In the meantime, there is a great need for larger, more all-encompassing studies administered by dental associations (such as the American Dental Education Association or the American Student Dental Association) with the means of reaching a greater number of dental students and faculty, to further understand the required educational interventions that would be most effective in instructing about antibiotic stewardship. Within the field of dentistry as a whole, we are currently in a somewhat challenging but opportunistic position where we have now accumulated a substantial amount of knowledge and data regarding antibiotic prescribing and the need for stewardship within medicine and, to a lesser but still significant degree, dentistry. The time has arrived where we need to advance beyond the discussion phase. Initial actions, in the form of antibiotic stewardship programs and clearly defined prescribing guidelines, need to be implemented now within dentistry.

Conclusion

Despite limitations in survey distribution design and a lower number of overall respondents than we had hoped for, this preliminary survey provided valuable information regarding the effectiveness of the current educational curriculums among U.S. dental schools surrounding the subjects of antibiotic use within dentistry and antimicrobial resistance. Insight was gained into the knowledge, attitudes, and beliefs of many 3rd and 4th year U.S. dental students and several academic deans and department chairs within these schools. Overall, 71% of dental students responding to this survey reported that they felt as though they could benefit from more education regarding antibiotics, and the majority of both survey groups agreed that dentistry should play an important role in reducing antimicrobial resistance. Unfortunately, there still appears to be limited awareness regarding the topic of antimicrobial stewardship among dental students, who could greatly benefit from more clearly defined and more apparent clinical guidelines within many of the dental disciplines. Despite lectures being reported as the most widely used teaching format among dental students, direct patient care was actually believed to be the most helpful teaching format for this topic of study. Full-time faculty appear to have the greatest influence on the clinical decision making regarding antibiotic prescribing habits among students. Therefore, it is of utmost importance that all academic faculty are fully aware of the

most current prescribing guidelines within each facet of dentistry and follow an evidence-based practice philosophy. With even minimal enhancements to the educational curriculum and clinical teachings regarding prudent antibiotic use, we have a great opportunity to lower the number of inappropriate antibiotics being prescribed in the future by correctly educating our current students at all levels of educational influence. However, additional research is still needed in order to fully determine which teaching formats and specific content should be utilized in order to provide future practitioners with the information needed to use antibiotics adequately within dentistry. This will be simplified as more clearly defined prescribing guidelines are made available among dental specialties, organizations, and associations. In the meantime, there is a great need for larger, more all-encompassing studies, proposedly administered by those dental associations with a more successful and influential means of reaching a larger number of dental students and faculty, to further understand the required educational interventions that are most effective in instructing about antibiotic indications and stewardship. Improvements to the educational curriculum regarding the responsible use of antibiotics, along with the implementation of stewardship programs within dentistry as a whole are strongly encouraged.

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Appendices

Appendix 1: Academic Deans and Department Chairs Survey

Antibiotics and Antimicrobial Resistance in Dentistry

Dear Colleagues,

The following online survey is for research. This study is conducted by an endodontics resident from Virginia Commonwealth University School of Dentistry. This study has been reviewed and declared exempt by the institutional review board [Reference #HM20012221]. The purpose of this study is to evaluate the perception among academic deans and department chairs regarding antibiotics and antimicrobial resistance in the dental student curriculum. Your response to this survey can help us evaluate current understanding in the field and improve communication amongst researchers, clinicians, educators, and students.

It will take approximately 10 minutes to complete. The survey can be completed on personal computers or mobile devices.

The survey is completely voluntary.

Thank you very much for your time.

Sincerely,
Magdalena Holz, DDS
VCU Endodontics Resident, Class of 2019

If you have any further questions, you may contact the research team at:

Garry L. Myers, D.D.S. (gmyers3@vcu.edu)
Magdalena Holz, D.D.S. (holzms@vcu.edu)
Department of Endodontics
VCU School of Dentistry
520 N. 12th St.
Richmond, VA 23298
(804) 828-6083

What is the region of your dental school?

- Northeast
- South
- Midwest
- West

What is your position?

- Academic Dean
- Department Chair
- Other

Please describe your position:

Which department do you chair?

What is your age:

What is your gender?

- Male
 Female
 Prefer not to answer

Do you currently have established clinical guidelines for antibiotic prescribing within any disciplines/departments at your dental school?

- Yes
 No

Which disciplines have established clinical guidelines for antibiotic prescribing?

- Endodontics
 General Practice
 Oral Diagnosis
 Oral Surgery
 Pediatrics
 Periodontics
 Institution-wide
 Other

Please list any other disciplines that have established clinical guidelines for antibiotic prescribing:

Which courses currently provide didactic education regarding antibiotics within the dental school curriculum?

- Community Dentistry
 Endodontics
 Epidemiology
 Microbiology
 Periodontics
 Pharmacology
 Oral Surgery
 Other
 None

Please list any other courses that provide didactic education on antibiotics within your dental school curriculum.

How would you rate the education regarding appropriate use of antibiotics in the dental school curriculum?

- Very useful
 Useful
 Neutral
 Not useful
 Not at all useful

How many hours of training in principles and indications of antibiotic use do the dental students receive during their 4 years of study?

- 0-10 hours
 11-20 hours
 21-40 hours
 41-60 hours
 60+ hours

Which of the teaching formats do you think have been most helpful in the education of dental students regarding antibiotics? [Please select up to 3]

- Lectures
 Clinical vignettes/Clinical case discussions
 E-learning (self-training)
 Web-based server software learning platform (e.g. Blackboard Learning System or other electronic learning environment)
 Clinical Care
 Specialty rotations/training
 External rotations
 Other

Is antimicrobial resistance currently being taught in the dental school curriculum?

- Yes
 No

Which departments/disciplines currently provide clinical training regarding antibiotics within the dental school curriculum?

- General Practice
 Pediatrics
 Endodontics
 Oral Surgery
 Oral Diagnosis
 Periodontics
 Institution-wide
 Other
 None

Do you think students could benefit from more education on antibiotic selection and indications at your dental school?

- Yes
 No
 I think they are receiving adequate training

Are there any antibiotic stewardship/monitoring protocols in place at your institution?

- Yes
 No
 Unsure

Please describe your antibiotic stewardship/monitoring protocols in place at your institution:

On a scale of 0-10, how important do you perceive this topic to be within the dental curriculum? Note: 0 being least important and 10 being most important

What percentage of antibiotic prescriptions within dentistry do you think are found to be unnecessary or inappropriate?

- < 1%
 1-20%
 21-40%
 41-60%
 61-80%
 81-100%
-

The field of dentistry should play an important role in reducing antimicrobial resistance?

- Strongly Disagree Disagree Neutral Agree Strongly Agree
-

Dental students can contribute in reducing/controlling antibiotic resistance?

- Strongly Disagree Disagree Neutral Agree Strongly Agree
-

Any additional comments or suggestions to improve antibiotic prescribing within dentistry or the dental student curriculum, please add them here:

Appendix 2: Dental Student Survey

Antibiotics and Antimicrobial Resistance in Dentistry

Dear Colleagues,

The following online survey is for research. This study is conducted by an endodontics resident from Virginia Commonwealth University School of Dentistry. This study has been reviewed and declared exempt by the institutional review board [Reference #HM20012221]. The purpose of this survey is to evaluate the knowledge, training, and perception among 3rd and 4th year dental students regarding antibiotics and antimicrobial resistance. Your response to this survey can help us evaluate current understanding in the field and improve communication amongst researchers, clinicians, educators, and students.

It will take approximately 10 minutes to complete. The survey is anonymous. We do not collect personal information to identify you. The survey can be completed on personal computers or mobile devices.

The survey is completely voluntary.

Thank you very much for your time.

Sincerely,
Magdalena Holz, DDS
VCU Endodontics Resident, Class of 2019

If you have any further questions, you may contact the research team at:

Garry L. Myers, D.D.S. (gmyers3@vcu.edu)
Magdalena Holz, D.D.S. (holzms@vcu.edu)
Department of Endodontics
VCU School of Dentistry
520 N. 12th St.
Richmond, VA 23298
(804) 828-6083

What is your current year of study:

- 1st Year (Class of 2021)
- 2nd Year (Class of 2020)
- 3rd Year (Class of 2019)
- 4th Year (Class of 2018)
- Other

Please describe your status as a student:

What is the region of your dental school?

- Northeast
- South
- Midwest
- West

What is your age?

What is your gender?

- Male
 Female
 Prefer not to answer

What are your plans following graduation?

- Private practice
 Academia
 Public practice [FQHC]
 Corporate practice
 Residency
 Other

Which residency are you most interested in:

- Advanced Education in General Dentistry
 Dental Public Health
 Endodontics
 General Practice Residency
 Oral and Maxillofacial Radiology
 Oral and Maxillofacial Surgery
 Oral and Maxillofacial Pathology
 Orthodontics
 Pediatric Dentistry
 Periodontics
 Prosthodontics

Please describe your plans following graduation:

How would you rate your dental education regarding appropriate use of antibiotics so far in your dental school curriculum?

- Very useful
 Useful
 Neutral
 Not useful
 Not at all useful
 I have not received any education so far

Which department/courses do you feel you have gained the majority of your decision-making skills and knowledge regarding antibiotic prescribing practices? [Please select up to 3]

- Community Dentistry
 Endodontics
 Epidemiology
 Microbiology
 Periodontics
 Pharmacology
 Oral Diagnosis/Oral Medicine
 Oral Surgery
 Other

Please list any other departments or courses where you feel you gained the majority of your decision making skills and knowledge regarding antibiotic prescribing practices.

How many hours of training in principles of antibiotic use do you think you have received to date in your dental education?

- 0-10 hours
- 11-20 hours
- 21-40 hours
- 41-60 hours
- 61+ hours

What kind of teaching format has been used during your education on antibiotics? [Choose all that apply]

- Lectures
- Clinical vignettes/Clinical case discussions
- E-learning (self-training)
- Web-based server software learning platform (e.g. Blackboard Learning System or other electronic learning environment)
- Direct patient care
- Other

Please describe any other teaching formats that were used to educate you about antibiotics.

Which of the teaching formats do you feel were most helpful in your education and understanding related to antibiotics? [Please select up to 3]

- Lectures
- Clinical vignettes/Clinical case discussions
- E-learning (self-training)
- Web-based server software learning platform (e.g. Blackboard Learning System or other electronic learning environment)
- Direct patient care
- Specialty rotations
- External rotations
- Other

Please describe any other teaching formats that you feel were most helpful in your education about antibiotics.

Do you currently have established clinical guidelines for antibiotic prescribing within any of the following disciplines at your dental school? [Choose all that apply]

- Endodontics
- General Practice
- Oral Diagnosis/Oral Medicine
- Oral Surgery
- Pediatrics
- Periodontics
- Institution-wide
- Other
- I don't know

Please list any other disciplines that have established clinical guidelines at your dental school.

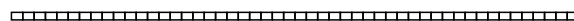
Who/what has had the greatest impact on your decision of when and how to prescribe antibiotics?
[Please select up to 3]

- Full-time faculty in clinic
 Part-time faculty in clinic
 Student peers
 Didactic courses
 Personal experience
 Personal research/investigation
 Other

Please describe any other factors that impact your decisions about prescribing antibiotics

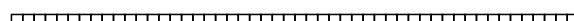
With your current level of understanding, how confident would you feel in the following scenarios when prescribing an antibiotic by yourself? Please use the scale provided to answer with 0 indicating not at all confident and 100 indicating very confident.

Making an accurate diagnosis of infection 0 100



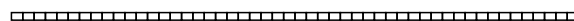
(Place a mark on the scale above)

Choosing the correct antibiotic 0 100



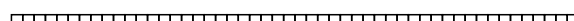
(Place a mark on the scale above)

Choosing the correct dose and interval of therapy 0 100



(Place a mark on the scale above)

Choosing the correct duration of the antibiotic 0 100



(Place a mark on the scale above)

Handling a patient who demands antibiotic therapy when it is not indicated 0 100



(Place a mark on the scale above)

Would you like more education on antibiotic selection and indications at your dental school?

- Yes
 No
 I think we are receiving adequate training

Do you believe that prescribing antibiotics when they are not indicated is professionally unethical?

- Yes
 No
 Unsure

Do you think that antibiotic resistance is a national problem?

- Yes
 No
 Unsure

The following scenarios are potential causes for resistance; please identify which, in your opinion, are the most or least important contributors to resistance?

	Great Impact	Some Impact	No Impact
Too many antibiotic prescriptions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Too many broad-spectrum antibiotics used	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Too long of a duration of antibiotic treatment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dosing of antibiotics are too low	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excessive use of antibiotics in livestock	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Poor hand hygiene	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of antibiotics being developed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prescribing antibiotics when the situation doesn't warrant its use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of effective diagnostic tools	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using the wrong antibiotic for the situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Patient non-compliance or self-medicating with antibiotic treatment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What percentage of antibiotic prescriptions within dentistry do you think are estimated to be unnecessary or inappropriate?

- < 1%
 1-20%
 21-40%
 41-60%
 61-80%
 81-100%

In a 10-year perspective, do you think the consequences of antibiotic resistance will affect your future work when caring for patients with dental infections?

- Not at all
 Rarely
 Occasionally
 Often
 Very Often

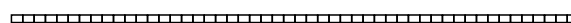
If so, what do you expect will be the greatest problem within healthcare?

- More expensive treatment for patients
- Fewer treatment alternatives
- Increased morbidity due to untreatable bacterial infections
- Increased spread of communicable diseases due to untreatable infections
- I don't know
- Other

Please describe any other problem you expect within healthcare:

On a scale of 0-100, with 0 being the least and 100 being the most, how important do you perceive this topic to be within dental education?

0 100



(Place a mark on the scale above)

Are you familiar with the term "antimicrobial stewardship"?

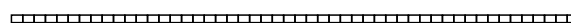
- Very familiar
- Familiar
- Not Familiar - I've heard the term, but am not sure what it is about
- Not at all familiar - I've never heard it before

Dentistry should play an important role in reducing antimicrobial resistance

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

How interested are you in playing a role in this improvement through better self-monitoring and antibiotic stewardship? Please use the scale provided to answer with 0 indicating not at all and 100 indicating very interested.

0 100



(Place a mark on the scale above)

Please indicate your agreement with the following sentence: Dental students can contribute in reducing and controlling antibiotic resistance?

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Vita

Dr. Magdalena S. Holz was born on August 7, 1986 in Greenville, West Virginia. She received a Bachelor of Science in Biology from Concord University in 2009 before attending West Virginia University School of Dentistry where she earned a Doctor of Dental Surgery in 2014. She completed an Advanced Education in General Dentistry certificate at the Bay Pines VA Healthcare System in Bay Pines, Florida. After two years in private practice as a general dentist, Dr. Holz began her specialty training in the Advanced Dental Program in Endodontics at Virginia Commonwealth University. Dr. Holz is a member of the American Association of Endodontists, American Dental Association, and Virginia Dental Association. She will graduate with a Master of Science in Dentistry and a Certificate in Endodontics in June 2019.