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# Trends And Racial/Ethnic Disparities In Antibiotic Prescribing Practices Of Dentists In The United States

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# Abstract

## Objective

The aim of this study was to examine trends and racial/ethnic disparities in antibiotic prescribing practices of dentists in the United States.

## Methods

The US Medical Expenditure Panel Survey data for 1996-2013 was analyzed. Information on patient sociodemographic characteristics, dental visits, receipt of dental procedures, and type of antibiotics prescribed following visits was obtained. Descriptive statistics were calculated separately for each year. Logistic regression analyses were conducted to identify associations during the period with and without adjustment for dental procedures and sociodemographic characteristics. Survey weights were incorporated to handle the sampling design.

## Results

Nationally, the number of antibiotic prescribed at dental visits was estimated to be higher by 842,749 (0.4 percent) at year 2013 compared to the prescription level at 2003 were the population sociodemographic distribution kept at 2013 level. On average, the odds of prescribing antibiotics following dental care increased with each decade of study (OR: 1.10; 95% CI: [1.04, 1.17]) after adjusting for sociodemographic characteristics and receipt of dental procedures. Compared to Whites, Blacks had 21 percent (95% CI: 11%, 31%) higher odds of receiving a prescription for antibiotics from a dentist after adjusting for dental procedure and other sociodemographic characteristics.

## Conclusions

The prescription of antibiotics following dental visits increased over time after adjustment for sociodemographic characteristics and dental procedure. The probability of being prescribed antibiotics by dentists was higher for Blacks compared to Whites.


# Introduction

Common dental conditions are inflammatory in nature and associated with some type of bacteria. The use of antimicrobials for the treatment of the bacteria infection associated with common dental conditions without demonstrable systemic involvement is problematic. Surgical and operative interventions in the form of tooth extractions, composite restorations, and root canal therapy are some of the common definitive treatment for these conditions. In addition, there is little or no evidence in the literature to support the prescription of antibiotics as a definitive treatment for irreversible pulpitis, which is a common dental pathology [1], [2]. Antibiotics prescriptions at dental visits has cost and policy implications. The prescription of antibiotics by dentists following dental visits is of concern to policymakers, professional organizations, and public health advocates due to the potential for patients to develop antibiotic resistance.

Dental professionals need to exercise caution in prescribing antibiotics due to the documented evidence of adverse drug events and the potential for patients to develop antibiotic-resistant illnesses that could lead to death [3]. The *Antibiotics Resistance Threats in the United States* report of 2013 indicates that each year at least two million people are infected with antibiotic-resistant illnesses and at least 23,000 people die as a direct result of these infections in the United States. [4]. Studies document that about 50 percent of antibiotics prescribed in outpatient settings are unnecessary [5]-[8]. Suda et al. reported that the US expenditure for antibiotics prescribed in all healthcare settings totaled $10.7 billion in 2009, with a majority (61.5 percent) being from outpatient settings [9].

In 2010, 10 percent of the 258 million courses of antibiotics (or 833 prescriptions per 1,000 persons) were prescribed by dental providers in the United States [10], [11]. The prescription of antibiotics by dentists is

widespread [11], but there is limited evidence to demonstrate what proportion of this is necessary. To address the issue of unnecessary prescribing practices of antibiotics in dentistry, professional organizations such as the American Dental Association and the American Association for Pediatric Dentistry provided clinical guidelines to help improve prescribing practices [12]. Nonetheless, the extent to which these guidelines are followed by dentists is poorly understood and understudied. For example, Cherry et al. reported that dental providers' adherence to these guidelines for odontogenic infections in children is low [13]. While Lewis reported that at least 40 percent of dentists surveyed prescribed antibiotics at least thrice per working week in the United Kingdom [13], our study has the potential to shed some light on dentists' antibiotic prescribing practices in the United States.

To the best of our knowledge, prior to our study, no report has documented national trend estimates and examined racial/ethnic disparities in antibiotic prescribing practices of dentists in the United States. Previous studies have concentrated on the prescription of antibiotics for nontraumatic dental conditions in hospital emergency departments [14], antibiotics prophylaxis to prevent infective endocarditis [15]-[17] and the use of antibiotics for specific dental conditions, such as odontogenic infections [18], [19]. In addition, one study reported that black children were less likely to receive a prescription from the same physician per acute visit or per population/child/year after adjustment for age, gender, insurance type, and stratification by practice [20].

The aim of this study was to investigate trends and examine racial/ethnic disparities in antibiotic prescribing practices of dentists in the United States. In addition, we propose to test the following hypotheses. First, whether over time, there is a difference in the rate of antibiotics prescribed by dentists following a dental visit. Second, test whether there is a difference in the rates of antibiotics prescribed by dentists for various dental procedures after adjustment for sociodemographic characteristics. Third, test whether racial/ethnic minority patients were less likely to receive antibiotic prescriptions at dental visits compared to Whites after adjustment for sociodemographic characteristics and dental procedures.

# Methods

This secondary data analysis is based on cross-sectional study design of the Medical Expenditure Panel Survey (MEPS) database. The data source for this study was the household component of the MEPSs for the years 1996–2013. These surveys use complex sampling designs including stratification, clustering, multiple stages of selection, and oversampling techniques to provide nationally representative estimates on the use of healthcare services by the civilian non-institutionalized population of the United States. Data analyses were based on recommendations laid out by the National Health Interview Survey and the Agency for Healthcare Research and Quality for pooling data from multiple years [21].

Our analysis was guided by the conceptual framework that dentists' antibiotics prescription practices would be related to a patient's age, gender, insurance type, race/ethnicity, education, and receipt of dental procedure [20]. This conceptual framework is in line with identified factors associated with dental service utilization based on Andersen's behavioral model of health services use (modifications by Aday and Andersen, Andersen and Davidson) in the literature [22], [23]. In addition, all the chosen covariates included in our model were selected after a careful review of published literature on antibiotic prescription practices of physicians related to our research question as well as our study stated hypotheses. The person weights for each survey were appropriately adjusted so that the sum of the weights for the pooled datasets provided nationally representative estimates.

## Drug and procedure coding extraction

The prescribed medicine data from MEPS was used to assess whether antibiotic drugs (carbapenems, first through fourth generation cephalosporins, macrolides, ketolides, penicillinase resistant penicillins,

antipseudomonal penicillins, aminopenicillins, beta-lactamas inhibitors, natural penicillins, quinolones, sulfanomides, tetracyclines, lincomycin derivatives, glycylcyclines, and miscellaneous antibiotics) have been prescribed for a specific visit using the Multum Lexicon variables. The prescription data was then linked to visit data to determine the type of procedures performed and the method of payments at each visit, and further linked to the full consolidated data files to determine personal characteristics such as age, gender, race/ethnicity, and social economic status including education, marital status, and poverty.

The types of dental procedures included are diagnostic, preventive, restorative, periodontics, surgical, orthodontic, implant, Temporomandibular disorders (TMD)/Temporomandibular Joint Dysfunction (TMJ), root canal, or other procedures. Diagnostic procedures include x-rays and general exams or consultations. Preventive procedures include sealants, fluoride treatment, and cleanings. Restorative treatments include crowns, inlays, fillings, dentures, bridges, and repairs. Periodontic treatments include gum surgery, and periodontal recall visits. Surgical procedures include oral surgery, tooth extraction, and abscess treatment. “Other procedures” includes teeth whitening and other dental procedures. Since multiple types of procedures could be present at each visit, the presence/absence of each procedure type was coded as a binary variable.

## Statistical analyses

For descriptive analysis, we calculated the proportion of dental visits at which any antibiotic was prescribed and visits where specific procedures were performed. Then for all visits and visits where specific procedures were performed, we calculated the proportion of dental visits at which any antibiotics were prescribed yearly relative to mean over the whole study period to see the temporal trend. Logistic regression analyses were conducted to estimate the overall linear trend (in the log-odds scale) of the proportion of antibiotic prescription per visit during the period. This was done with and without adjustment for procedures (diagnostic, preventive, restorative, periodontics, surgical, orthodontic, implant, TMD/TMJ, root canal, or “other procedures”), and sociodemographic characteristics (age, gender, race, marital status, federal poverty level, education, primary source of payments). Separate procedure-specific analyses were also performed with and without adjusting for sociodemographic characteristics. Variable selection was based on literature evidence and clinical relevance and all analyses were adjusted for the survey design by incorporating survey weights. After obtaining the estimated odds ratio associated with each year, we calculated and reported the estimated odds ratio associated with each decade (10 years) to understand the long-term impact of the prescription trends using unit change formula $OR(decade) = OR(year)^{10}$. All analyses were performed with the following procedures: SURVEYFREQ, SURVEYMEANS and SURVEYREG, SURVEYLOGISTIC, SAS 9.4. An alpha level of 0.05 was used throughout to denote statistical significance. This study was approved by the Marquette University Institutional Review Board.

# Results

Records from 335,164 dental visits from MEPS respondents containing complete information representing 3,949,014,433 dental visits in the United States were reviewed. Of these, 14,828 (4.4 percent) representing 159,520,452 (4.0 percent) dental visits in the United States had an antibiotic prescription. Table **1** shows the descriptive statistics of antibiotic prescription rates, sociodemographic, and procedure types from 1996 to 2013. The annual proportion of visits with antibiotic prescriptions following dental visits ranged between 3.0 and 5.1 percent during the study period. The distribution of antibiotics prescribed by dentists by category are presented in Supporting Information Table S1. The top panel of Figure **1** shows the proportion of antibiotic prescriptions for all visits and for visits where specific procedures were performed. The number of antibiotic prescriptions by dentists was higher for surgical, root canal, periodontics, diagnostic, and implant procedures. Therefore, in the bottom panel we further show the temporal trend for the top five most frequent procedures as well as for all the procedures for which antibiotics were prescribed. We observed a major increase in antibiotic prescriptions in visits where implants were performed. The proportion of antibiotics prescribed for all visits showed a

dramatic decrease in the years 1996–2000, an increase in 2000–2003, and with fairly stable yearly decreases from 2003 to 2005, 2006 to 2007, 2008 to 2010, and 2011 to 2012. This was followed by an increase during the years 2012–2013. The data for surgical and root canal procedures showed similar decreases from 1996 to 2000, increases similar in level to 1996 and 2000 to 2003, and remained unchanged thereafter. The formal test for these trends are provided in Table 3.

**Table 1.** Study Population Characteristics and Dental Procedures: United States, 1996–2013

| | ***N* = 335,164**[*] | **Weighted %**[†] |
|---|---|---|
| Visits with an antibiotic prescription | 14,828 | 4.04 |
| Age (years) | | |
| 18–29 | 52,199 | 15.7 |
| 30–39 | 55,197 | 16.0 |
| 40–49 | 67,734 | 19.7 |
| 50–59 | 67,439 | 20.2 |
| 60–69 | 49,074 | 15.1 |
| 70+ | 43,521 | 13.4 |
| Gender | | |
| Male | 134,556 | 41.9 |
| Female | 200,608 | 58.1 |
| Race/ethnicity | | |
| Hispanic | 44,520 | 7.0 |
| Black | 34,473 | 6.7 |
| Asians and Pacific Islanders | 16,286 | 3.7 |
| White | 235,249 | 81.4 |
| Other | 4,636 | 1.2 |
| Marital status | | |
| Married | 203,072 | 60.7 |
| Widowed | 22,442 | 6.7 |
| Divorced | 37,723 | 11.2 |
| Separated | 5,867 | 1.4 |
| Never married | 66,060 | 20.0 |
| Federal poverty level (FPL) | | |
| <100% | 29,744 | 6.2 |
| 100–124% | 11,014 | 2.5 |
| 125–199% | 34,824 | 8.8 |
| 200–399% | 97,962 | 28.5 |
| ≥400% | 161,620 | 54.0 |
| Educational attainment | | |
| <High school | 42,436 | 9.2 |
| High school diploma or equivalent | 151,177 | 44.5 |
| College education | 100,756 | 32.7 |
| Advanced degree | 40,795 | 13.6 |
| Primary source of payments | | |
| Family/out of pocket | 141,267 | 42.7 |
| Medicaid | 19,618 | 3.7 |

| | | |
|---|---|---|
| Medicare | 2,517 | 0.7 |
| Private insurance | 150,856 | 47.4 |
| Other | 10,486 | 2.8 |
| Unclassified | 10,420 | 2.8 |
| Type of dental procedures | | |
| Diagnostic only[‡] | 34,842 | 9.9 |
| Preventive only[§] | 140,138 | 43.9 |
| Restorative | 90,009 | 26.7 |
| Periodontics | 9,747 | 2.9 |
| Surgical | 31,282 | 8.0 |
| Orthodontic | 11,892 | 3.2 |
| Implant | 2,968 | 0.9 |
| TMD/TMJ | 790 | 0.3 |
| Root canal | 14,137 | 4.1 |
| Other procedures | 7,691 | 2.4 |

*Excluding sample with 0 weight (i.e., data collected beyond survey design).
[†]Weighted version *N* = 3,949,014,433, the weighted percentage represents the estimated proportion of covariate distribution among whole US population rather than the surveyed subsample.
[‡]Excluding all other procedures.
[§]Excluding all other procedures except diagnostic procedures.

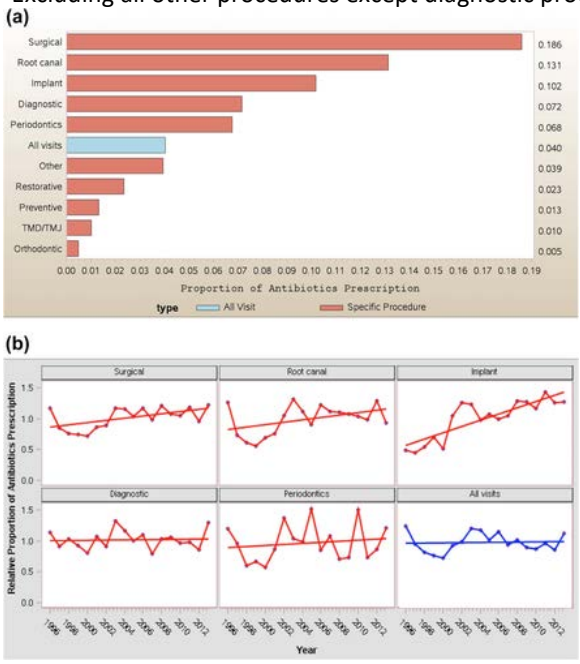


**Figure 1** Proportion of dental visits with antibiotics prescription for all visits or visits when each specific procedure was performed from 1996 to 2013. Figure (a) represents overall proportion of antibiotics prescription and all visits with prescription and all procedures. Figure (b) represents yearly relative proportion for the five most frequent precedures with antibiotics prescription and all procedures together (1 representing the overall average for the given procedure type). [Color figure can be viewed at **wileyonlinelibrary.com**]

The unadjusted analysis showed no significant change in the odds of being prescribed antibiotics at a visit. The estimated odds ratio (OR) was 1.01 (95% CI: [0.95, 1.08]) per decade. As shown in Table **2**, after adjustment for sociodemographic characteristics and type of dental procedures performed during the visit, the OR increased to 1.10 (95% CI: [1.04, 1.17]) per decade and was statistically significant. From our model, with the adjustment of

both sociodemographic and dental procedures, we estimated that for the population at year 2013, the number of antibiotic prescriptions was 10,516,394 (4.7 percent). Furthermore, should dentists continue to prescribe antibiotics at the same rate as in 2003, based on their sociodemographic and dental procedures, the number of prescriptions would be 9,673,645 (4.3 percent). This would reflect a somewhat excessive increase of 842,749 (0.4 percent) compared to a decade ago. Adjusting for year and dental procedure, females were estimated to have higher odds (OR 1.08; 95% CI: [1.02, 1.14]) of being prescribed antibiotics compared to males. Compared to Whites patients, Asians had lower odds (OR 0.81; 95% CI: [0.72, 0.92]), Blacks and Hispanics had higher odds (OR 1.21; 95% CI: [1.11, 1.31]), and (OR 1.06; 95% CI: [0.98, 1.15]) of receiving antibiotics following a dental visit, respectively. Patients with incomes below the poverty level had higher odds (OR 1.25; 95% CI: [1.14, 1.37]) of receiving antibiotics compared to the wealthiest group, and people paying out of pocket were more likely to be prescribed antibiotics than those with private insurance. As shown in Figure 1 and Table 2, patients who reported that they received a surgical procedure had the highest chance of being prescribed antibiotics (OR 5.54; 95% CI: [5.14, 5.96]), followed by those who had root canals (OR 3.88; 95% CI: [3.54, 4.26]), implants (OR 2.27; 95% CI: [1.92, 2.69]), and periodontal procedures (OR 1.86; 95% CI: [1.62, 2.14]).

**Table 2.** Results for Survey Logistic Regression Analysis Adjusting Sociodemographic Characteristics, Dental Procedures or Both

| | **Prescription per visit (OR (95% CI))** | | |
|---|---|---|---|
| **Variable** | **Adjust for sociodemographic characteristics**[†] | **Adjust for dental procedures**[‡] | **Adjustment for both**[§] |
| Year (per decade) | 1.05 (0.99,1.12) | 1.09 (1.03,1.16)* | 1.10 (1.04,1.17)* |
| Age (per 10 years) | 0.99 (0.97,1.01) | | 1.02 (1.00,1.04) |
| Gender | | | |
| Male | Reference | | Reference |
| Female | 0.98 (0.93,1.04) | | 1.08 (1.02,1.14)* |
| Race/ethnicity | | | |
| Hispanic | 1.13 (1.03,1.22) * | | 1.06 (0.98,1.15) |
| Black | 1.57 (1.45,1.70) * | | 1.21 (1.11,1.31)* |
| Asian or Pacific Islander | 0.82 (0.72,0.94) * | | 0.81 (0.72,0.92)* |
| White | Reference | | Reference |
| Other | 1.06 (0.85,1.32) | | 0.97 (0.78,1.20) |
| Marital status | | | |
| Married | Reference | | Reference |
| Widowed | 0.92 (0.81,1.04) | | 0.92 (0.81,1.05) |
| Divorced | 1.20 (1.10,1.30) * | | 1.11 (1.02,1.21)* |
| Separated | 1.43 (1.22,1.67) * | | 1.12 (0.94,1.33) |
| Never married | 0.94 (0.86,1.03) | | 1.02 (0.93,1.11) |
| Federal poverty level (FPL) | | | |
| <100% | 1.62 (1.49,1.77) * | | 1.25 (1.14,1.37)* |
| 100–124% | 1.58 (1.35,1.84) * | | 1.22 (1.03,1.44)* |
| 125–199% | 1.48 (1.36,1.62) * | | 1.20 (1.10,1.31)* |
| 200–399% | 1.22 (1.14,1.30) * | | 1.11 (1.03,1.18)* |
| ≥400% | Reference | | Reference |
| Educational attainment | | | |
| <High school | 1.52 (1.34,1.72) * | | 1.16 (1.03,1.31)* |

| | | | |
|---|---|---|---|
| High school diploma or equivalent | 1.43 (1.30,1.58) * | | 1.22 (1.11,1.35)* |
| College education | 1.11 (1.00,1.22) * | | 1.08 (0.98,1.19) |
| Advanced degree | Reference | | Reference |
| Primary source of payment | | | |
| Family/out of pocket | 1.33 (1.25,1.43) * | | 1.09 (1.02,1.17)* |
| Medicaid | 1.26 (1.11,1.43) * | | 0.99 (0.87,1.12) |
| Medicare | 1.03 (0.74,1.43) | | 0.92 (0.64,1.33) |
| Private insurance | Reference | | Reference |
| Other | 1.15 (0.98,1.34) | | 0.99 (0.85,1.15) |
| Unclassified | 0.90 (0.76,1.07) | | 0.88 (0.74,1.04) |
| Type of dental procedure include | | | |
| Diagnostic | | 1.78 (1.67,1.90) * | 1.76 (1.65,1.87)* |
| Preventive | | 0.29 (0.26,0.31) * | 0.30 (0.28,0.32)* |
| Restorative | | 0.55 (0.50,0.60) * | 0.54 (0.50,0.59)* |
| Periodontics | | 1.83 (1.59,2.11) * | 1.86 (1.62,2.14)* |
| Surgical | | 5.89 (5.47,6.35) * | 5.54 (5.14,5.96)* |
| Orthodontic | | 0.13 (0.07,0.25) * | 0.14 (0.07,0.26)* |
| Implants | | 2.23 (1.89,2.63) * | 2.27 (1.92,2.69)* |
| TMD/TMJ | | 0.27 (0.08,0.87) * | 0.28 (0.09,0.89)* |
| Root canal | | 3.89 (3.55,4.27) * | 3.88 (3.54,4.26)* |
| Other procedures | | 1.02 (0.86,1.21) | 1.02 (0.86,1.21) |

*Denotes statistically significant at 0.05 level.

†Adjusted for age, gender, race, marital status, federal poverty level, education, primary source of payments for the visit.

‡Adjusted for whether each of the following dental procedure is performed: diagnostic, preventive, restorative, periodontics, surgical, orthodontic, implants, TMD/TMJ, root canal, other procedures.

§Adjusted for age, gender, race, marital status, federal poverty level, education, primary source of payments for the visit and whether each of the following dental procedure is performed: diagnostic, preventive, restorative, periodontics, surgical, orthodontic, implants, TMD/TMJ, root canal, other procedures.

Table 3 presents separate logistic regression analysis results for the year effect of antibiotics by dental procedure, specifically from 1996 to 2013 with or without adjustment for sociodemographic characteristics. A somewhat decreasing or stable trend of antibiotics use was observed for most procedures, but having implants, surgical procedures, and root canals were associated with increasing odds (OR 1.77 (95% CI: [1.32, 2.36]), 1.27 (95% CI: [1.17, 1.38]), and 1.25 (95% CI: [1.09, 1.42])) of getting a prescription for antibiotics per decade, respectively. These increases were all statistically significant. The bottom panel of Figure 1 shows the total number of visits for each procedure over years, with increases in antibiotic prescriptions following dental implant procedures and a slightly decreasing trend for surgical and root canal therapy over time. With the results from Table 3, this suggests that the greatest increase in antibiotic prescriptions was contributed by implant procedures.

**Table 3.** Results of Survey Logistic Regression Analysis: The Year Effect (in the Unit of 10 Years) on Antibiotic Prescription by Each Dental Procedures Separately with or Without Adjusting for sociodemographic Characteristics from 1996 to 2013

| Dental procedure | Antibiotics prescription per visit | |
|---|---|---|
| | **Unadjusted odds ratio per decade, 95% CI** | **Adjusted[‡] odds ratio per decade, 95% CI** |
| Diagnostic only[‡] | 1.02 (0.91,1.15) | 1.10 (0.98,1.24) |
| Preventive only[§] | 0.86 (0.76, 0.98)[*] | 0.81 (0.71, 0.92)[*] |
| Restorative | 1.12 (0.97, 1.28) | 1.12 (0.97, 1.29) |
| Periodontics | 1.10 (0.89, 1.36) | 1.10 (0.88, 1.37) |
| Surgical | 1.25 (1.15, 1.36)[*] | 1.27 (1.17, 1.38)[*] |
| Orthodontia | 0.73 (0.32, 1.68) | 0.57 (0.30,1.08) |
| Implants | 1.76 (1.31, 2.38)[*] | 1.77 (1.32, 2.36)[*] |
| TMD/TMJ | 0.56 (0.32, 0.97)[*] | 1.29 (0.20, 8.54) |
| Root canal | 1.23 (1.08, 1.40)[*] | 1.25 (1.09, 1.42)[*] |
| Other procedures | 1.03 (0.76, 1.39) | 1.08 (0.79, 1.46) |

*Denotes statistically significant at 0.05 level.

[†]Adjust for age, gender, race, marital status, federal poverty level, education, primary source of payments for the visit.

[‡]Excluding all other procedures.

[§]Excluding all other procedures except diagnostic procedures.

## Discussion

This study used a nationally representative sample of US adults to provide estimates on trends and to examine racial/ethnic disparities in the prescription of antibiotics to patients by dentists following dental care. Studies on antibiotic prescription in dentistry had, until now focused on the types of dental conditions for which antibiotics are prescribed, with little or no documentation on trend information related to specific dental procedures.

In terms of the first hypothesis, although the rate of antibiotic prescription at dental visits showed a nonlinear pattern over short periods, the significant linear trend found in this study provides a good estimate of the average effects during the long term. Investigators found that the number of antibiotics prescribed at dental visits was estimated to be higher by 842,749 (0.4 percent) compared to a decade ago. This result is consistent with findings in a study conducted in Canada which indicated that dentists' prescription of antibiotics had increased significantly from 1996 to 2013 **24**. It is also consistent with increases seen in the number of antibiotics prescribed by US emergency department physicians for nontraumatic dental conditions as reported by Okunseri et al. **25**. The identified trend increase in our study is of concern given that most common dental pathology is localized and there are few indications for systemic antibiotic prescriptions for dental care **15**.

We found that on average, after adjustment for sociodemographic characteristics and dental procedures, the odds of visits resulting in antibiotic prescriptions increased significantly at an average rate of 10 percent per decade during the study period. Although specific reasons for increased antibiotic prescription by dentists following dental procedures is beyond the scope of this study, possible reasons could include a lack of clear understanding of the pathophysiology of common dental diseases. Other reasons include inadequate understanding of the pharmaco-therapeutic indications for the prescription of antibiotics and possibly the existence of mixed information on guidelines related to antibiotic prophylaxis for infective endocarditis.

In our study, we proposed to test whether there was a difference in the rates of antibiotic prescription by dentists for various dental procedures after adjustment for sociodemographic characteristics. We found that the proportion of visits with antibiotic prescriptions following dental visits ranged between 3.0 and 5.1 percent in the years from 1996 to 2013. Root canal or endodontic procedures and surgical procedures contributed significantly to the increase in antibiotics prescribed at dental visits during this study period. The finding related

to root canal therapy is surprising given the literature evidence that a clear majority of endodontic infections with no sign of systemic infection or involvement are best managed without antibiotics [26-28]. Although not directly examined in this study, investigators believe that the high rates of antibiotic prescriptions following surgical procedures might be connected with the controversy that still exists regarding the benefits of antibiotic prescriptions following third molar removal in the literature. For example, Lang et al. reported that antibiotic prescription was associated with a decrease in the complication of the risk of inflammation following third molar removal, regardless of type, dose, frequency or pattern of delivery [29]. Aragon-Martinez et al. reported that in a healthy patient, the prescription of amoxicillin has no benefit, but rather poses the risk of such patients developing dysbiosis-related diseases [30].

Another procedure that contributed to the increase in antibiotic prescriptions was dental implants. Ahmad and colleague indicated that the prescription of antibiotics for implant procedures is controversial for clinically healthy and moderate-risk individuals, and concluded that there is no benefit from the prescription of antibiotics for low and moderate-risk dental implant patients [31]. Conversely, three studies based on systematic reviews of randomized control trials concluded that antibiotic prophylaxis with implant placement reduces the risk for implant loss [32-34]. These findings could be plausible reasons for the increases in antibiotic prescriptions following implant procedures in the United States. Nonetheless, the postoperative benefits of antibiotics and the most appropriate type of antibiotics for implant procedures are unknown. To minimize unnecessary antibiotic prescription by dentists for implant procedures, more continuing education would be needed to examine the attendant public health risks versus benefits.

An interesting finding in this study was related to our hypothesis about whether racial/ethnic minority adults were less likely to receive antibiotic prescriptions at dental visits compared to Whites after adjustment for available covariates. Blacks and Hispanics were more likely to receive a prescription for antibiotics at a dental visit after adjusting for procedure type. However, the association was stronger and more robust for Blacks than for Hispanics after adjusting for sociodemographic characteristics and dental procedures. This finding is in contrast to racial/ethnic disparities documented in the prescription of analgesics and antibiotics in EDs for fracture treatment and nontraumatic dental conditions [25, 35]. In addition, this finding could be a reflection of previously identified higher burdens of dental disease in these population groups. However, the use of antibiotics should not be a replacement for the receipt of definitive dental care by racial and ethnic minorities.

Limitations of this secondary data analysis study should be mentioned. First, the dataset did not include details such as the daily defined dosage (DDD) of antibiotics prescribed. It also did not indicate whether the prescriptions were filled and the medication taken by patients. Second, researchers were unable to identify whether the prescriptions were issued by dental specialists or general dental practitioners, and since the study used a cross-sectional design, we are unable to demonstrate a cause and effect relationship. Third, our data could be affected by misclassification, which could lead to under- or over-estimation of our outcomes. Fourth, our study is based on self-reports and could be affected by recall bias. Finally, our data did not include information on participants' existing medical conditions beyond the dental procedure information relevant to our study. Despite these limitations, the study was based on a nationally representative sample with information covering more than 15 years. This dataset is highly capable of providing trend estimates and information on associated factors.

Our study provides the much-needed baseline information on antibiotic prescription trends following dental treatment by dentists in the United States. It also raises dentists' awareness of how they could (inadvertently) be contributing to antibiotic overprescribing in the United States. The prescription of antibiotics in dental care has policy, practice, and cost implications that are important in understanding the severity of the problem of unnecessary prescription [36]. This study demonstrates that after adjusting for sociodemographic characteristics and dental visit type, there was an increase in the proportion of dental visits with antibiotics prescribed during

the last two decades. The odds of receiving a prescription for antibiotics were higher for women and certain other minority groups. Our findings suggest a need to educate dentists on how to avoid unnecessary prescription of antibiotics to prevent the public health risks associated with antibiotics resistance.

## References


1 Cope A, Francis N, Wood F, Mann MK, Chestnutt IG. Systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults. *Cochrane Database Syst Rev.* 2014;( 6): CD010136.

2 Agnihotry A, Fedorowicz Z, Van Zuuren EJ, Farman AG, Al-Langawi JH. Antibiotic use for irreversible pulpitis. *Cochrane Database Syst Rev.*2016; **2**: CD004969.

3 McCaig LF. Trends in antimicrobial drug prescribing among office-based physicians in the United States. *JAMA.* 1995; **273**( 3): 241- 2.

4 Centers for Disease Control and Prevention. Antibiotic resistance threats in the United States, 2013. [accessed 2016 April 24]. Available from: http://www.cdc.gov/drugresistance/threat-report-2013/

5 Ebert SC. Factors contributing to excessive antimicrobial prescribing. *Pharmacotherapy.* 2007; **27**: 126S- 30S. doi: 10.1592/phco.27.10part2.126S.

6 Centers for Disease Control and Prevention (CDC). Office-related antibiotic prescribing for persons aged ≤14 years — United States, 1993—1994 to 2007—2008. *MMWR Morb Mortal Wkly Rep.* 2011; **60**( 34): 1153- 6.

7 Pichichero ME. Dynamics of antibiotic prescribing for children. *JAMA.* 2002; **287**( 23): 3133- 5.

8 Shapiro DJ, Hicks LA, Pavia AT, Hersh AL. Antibiotic prescribing for adults in ambulatory care in the USA, 2007–09. *J Antimicrob Chemother.* 2014; **69**( 1): 234- 40.

9 Suda KJ, Hicks LA, Roberts RM, Hunkler RJ, Danziger LH. A national evaluation of antibiotic expenditures by healthcare setting in the United States, 2009. *J Antimicrob Chemother.* 2013; **68**: 715- 8.

10 Hick LA, Taylor TH, Hunkler RJ. U.S. outpatient antibiotic prescribing, 2010. *N Engl J Med.* 2013; **368**: 1461- 2.

11 Jaunay T, Sambrook P, Goss A. Antibiotics prescribing practices by South Australian general practitioners. *Aust Dent J.* 2000; **45**: 179- 86.

12 Meeker D, Linder JA, Fox CR, Friedberg MW, Persell SD, Goldstein NJ, Knight TK, Hay JW, Doctor JN. Effect of behavioral interventions on inappropriate antibiotics prescribing among primary care practices. A randomized clinical trial. *JAMA.* 2016; **315**( 6): 562- 70.

13 Lewis MA. Why we must reduce dental prescription of antibiotics: European Union Antibiotic Awareness Day. *Br Dent J.*2008; **205**( 10): 537- 8.

14 Sun BC, Chi DL, Schwarz E, Milgrom P, Yagapen A, Malveau S,Chen Z, Chan B, Danner S, Owen E, Morton V, Lowe RA. Emergency department visits for nontraumatic dental problems: a mixed-methods study. *Am J Public Health.* 2015; **105**( 5): 947- 55.

15 Dar-Odeh NS, Abu-Hammad OA, Al-Omiri MK, Khraisat AS,Sameh AA. Antibiotic prescribing practices by dentists: a review. *Ther Clin Risk Manag.* 2010; **6**: 301- 6.

16 Tong DC, Rothwell BR. Antibiotic prophylaxis in dentistry: a review and practice recommendations. *J Am Dent Assoc.* 2000; **131**( 3): 366- 74.

17 Nelson CL, Van Blaricum CS. Physician and dentist compliance with American Heart Association guidelines for prevention of bacterial endocarditis. *J Am Dent Assoc.* 1989; **118**( 2): 169- 73.

18 Cherry WR, Lee JY, Shugars DA, White RP, Vann WF. Antibiotics use for treating dental infections in children. *JADA.* 2012; **143**( 1): 31- 8.

19 Epstein JB, Chong S, Le ND. A survey of antibiotics use in dentistry. *JADA.* 2000; **131**: 1600- 9.

20 Gerber JS, Prasad PA, Localio AR, Fiks AG, Grundmeier RW, Bell LM, Wasserman RC, Rubin DM, Keren R, Zaoutis TE. Racial differences in antibiotic prescribing by primary care pediatricians. *Pediatrics.* 2013; **131**: 677- 84.

21 Medical Expenditure Panel Survey (MEPS). Rockville, MD: Agency for Healthcare Research and Quality; 2015. Available from: http://www.ahrq.gov/research/meps/index.html
22 Aday LA, Andersen R. A framework for the study of access to medical care. *Health Serv Res.* 1974; **9**( 3): 208- 20.
23 Andersen RM. Revisiting the behavioral model and access to medical care: does it matter?. *J Health Soc Behav.* 1995; **36**( 1): 1- 10. doi: 10.2307/2137284.
24 Marra F, George D, Chong M, Sutherland S, Patrick DM.Antibiotic prescribing by dentists has increased why?. *JADA.* 2016; **147**( 5): 320- 7.
25 Okunseri C, Okunseri E, Thorpe JM, Xiang Q, Szabo A.Medications prescribed in emergency departments for nontraumatic dental condition visits in the United States. *Med Care.* 2012; **50**( 6): 508- 12.
26 Baumgarter JC, Smith JR. Systemic antibiotics in endodontic infections. In: AF Fouad, editor. *Endodontic microbiology*. 1st ed. Iowa: Wiley-Blackwell; 2009. p. 225- 41.
27 Walton R. Endodontic emergencies and therapeutics. In: M Torabinejad, R Walton, editors. *Endodontics principles and practice*.4th ed. St Louis: CV Saunders; 2009. p. 153- 4.
28 Baumgarter JC. Antibiotics in endodontic therapy. In: MG Newman, AJ Winkelhoff, editors. *Antibiotics and antimicrobial use in dental practice*. 2nd ed. Carol Stream, IL: Quintessence Publishing Co, Inc; 2001. p. 143- 57.
29 Lang MS, Gonzalez ML, Dodson TB. Do antibiotics decrease the risk of inflammatory complications after third molar removal in community practices?. *J Oral Maxillofac Surg.* 2017; **75**( 2): 249- 55.
30 Aragon-Martinez OH, Isiordia-Espinoza MA, Tejeda Nava FJ,Aranda Romo S. Dental care professionals should avoid the administration of amoxicillin in healthy patients during third molar surgery: is antibiotic resistance the only problem? *J Oral Maxillofac Surg.* 2016; **74**: 1512- 3.
31 Ahmad N, Saad N. Effects of antibiotics on dental implants: a review. *J Clin Med Res.* 2012; **4**( 1): 1- 6.
32 Esposito M, Grusovin MG, Loli V, Coulthard P, Worthington HV.Does antibiotic prophylaxis at implant placement decrease early implant failures? A Cochrane systematic review. *Eur J Oral Implantol.*2010; **3**( 2): 101- 10.
33 Lund B, Hultin M, Tranaeus S, Naimi-Akbar A, Klinge B. Complex systematic review - perioperative antibiotics in conjunction with dental implant placement. *Clin Oral Implants Res.* 2015; **26**( Suppl 11): 1- 14.
34 Veitz-Keenan A, Keenan JR. Antibiotic use at dental implant placement. *Evid Based Dent.* 2015; **16**( 2): 50- 1.
35 Todd KH, Samaroo N, Hoffman JR. Ethnicity as a risk factor for inadequate emergency department analgesia. *JAMA.* 1993; **269**: 1537- 9.
36ADA News. CDC epidemiologist highlights antibiotic overuse at the ADA CE course. 2016 [accessed 2017 May 6];**47**(1):1,6. Available from: http://editiondigital.net/publication/index.php?i=286287&m=&l=&p=1#{“page”:6,“issue_id”:286287}

# Supporting Information

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| Filename | Description |
|---|---|
| jphd12245-sup-0001-suppinfo1.pdf106.1 KB | **Table S1:** Distribution of Antibiotic Prescription by Category: 1996-2013. |

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**Table S1:** Distribution of Antibiotic Prescription by Category: 1996-2013.

| **Visits with an Antibiotic Prescription** | **N= 14,828[1]** |
|---|---|
| **Antibiotic Category** | |
| Carbapenems | 0 |
| 1st Generation Cephalosporins | 821 |
| 2nd Generation Cephalosporins | 22 |
| 3rd Generation Cephalosporins | 16 |
| 4th Generation Cephalosporins | 0 |
| Macrolides | 2211 |
| Ketolides | 0 |
| Penicillinase Resistant Penicillins | 14 |
| Antipseudomonal Penicillins | 0 |
| Aminopenicillins | 6246 |
| Beta-Lactamase Inhibitors | 112 |
| Natural Penicillins | 3842 |
| Quinolones | 100 |
| Sulfonamides | 22 |
| Tetracyclines | 282 |
| Lincomycin Derivatives | 1003 |
| Glycylcyclines | 0 |
| Miscellaneous Antibiotics | 79 |

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[1]excluding sample with 0 weight (i.e., data collected beyond survey design).

**Table S1:** Distribution of Antibiotic Prescription by Category: 1996-2013.

| Visits with an Antibiotic Prescription | N= 14,8281 |
|---|---|
| Antibiotic Category | |

| | |
|---|---|
| Carbapenems | 0 |
| 1st Generation Cephalosporins | 821 |
| 2nd Generation Cephalosporins | 22 |
| 3rd Generation Cephalosporins | 16 |
| 4th Generation Cephalosporins | 0 |
| Macrolides | 2211 |
| Ketolides | 0 |
| Penicillinase Resistant Penicillins | 14 |
| Antipseudomonal Penicillins | 0 |
| Aminopenicillins | 6246 |
| Beta-Lactamase Inhibitors | 112 |
| Natural Penicillins | 3842 |
| Quinolones | 100 |
| Sulfonamides | 22 |
| Tetracyclines | 282 |
| Lincomycin Derivatives | 1003 |
| Glyeyleyclines | 0 |
| Micellaneous Antibiotics | 79 |

[1]excluding sample with 0 weight (i.e., data collected beyond survey design).