PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY

Oral Health Behaviors and Availability of Dental Services Among Children and Adults

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About the Journal

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GUEST EDITORIAL

Addressing Oral Health Inequities, Access to Care, Knowledge, and Behaviors

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NON–PEER REVIEWED

Oral health is essential to overall health (1), and dental public health is a field of public health and a specialized field of dentistry that focuses on improving access to oral health care and understanding the factors that contribute to improving oral health from a population health perspective (2). This collection of articles in *Preventing Chronic Disease* (PCD), "Oral Health Behaviors and Availability of Dental Services Among Children and Adults," features 8 articles that discuss contemporary dental public health challenges and opportunities. These include inequities in access to dental care, disparities in the prevalence of oral disease, risk behaviors related to oral disease, the relationship between oral health and chronic diseases, and the effect of the COVID-19 pandemic on oral health.

Healthy People 2030 is the fifth iteration of national health objectives for the United States, and like previous editions, includes oral health (3). These objectives are categorized by health conditions, health behaviors, and populations, and the 11 that deal with oral health serve as a framework for articulating how findings and recommendations presented in this PCD collection align with established strategies to improve national oral health outcomes.

Healthy People 2030 oral health objective 6 is to reduce the proportion of adults aged 45 years or older with moderate or severe periodontitis, a disease linked to chronic diseases such as diabetes (4), adverse pregnancy outcomes (5), atherosclerotic cardiovascular disease (6), rheumatoid arthritis (7), Alzheimer's disease (8), chronic obstructive pulmonary diseases (9), nonalcoholic fatty liver disease (10), and others. In the article by Seitz et al, "Current Knowledge on Correlations Between Highly Prevalent Dental Conditions and Chronic Diseases: An Umbrella Review," the authors examined 1,249 systematic reviews on the relationships between oral diseases and chronic diseases and included 32 in their qualitative synthesis (11). They found that periodontitis was the dental condition most frequently correlated with chronic systemic diseases. Conversely, type 2 diabetes was the chronic systemic disease that had the most frequently observed correlations with dental conditions. Most dental–chronic disease correlations were found between periodontitis and diabetes and between periodontitis and cardiovascular disease. The authors suggest that these correlations should be factored into care plans for people with comorbid or multimorbid dental and chronic disease conditions. They also suggest that more awareness is needed about evidence on correlations between dental conditions and chronic diseases and potential opportunities for medical–dental integration in delivery of care. They highlight the need for more research on the causal links between dental conditions and chronic diseases. In addition, longitudinal research studies are needed to document the direction of causality between oral health and systemic diseases.

Access to dental care for prevention and treatment is critical to ensure optimal oral health. Healthy People 2030 oral health objective 8 is to increase the proportion of children, adolescents, and adults who use the oral health care system. Increasing use of the oral health system is also a Leading Health Indicator, a small subset of high-priority Healthy People 2030 objectives selected to drive action toward improving health and well-being in the United States (12). Unfortunately, access to oral health care is a challenge: only 43% of the US population had a dental visit in 2015 (13). Moreover, some segments of the population — certain racial/ethnic minority groups, people living in poverty, and people living in rural areas — have even less access to dental care. Overall, people of all ages living in rural America have about 8% (children aged ≥2 y) to 10% (adults aged 18–64 y) less access to dental services compared with their urban counterparts. Children in rural areas are 5% less likely to receive preventive dental care than children in urban areas, and adults in rural areas are 7% more likely to have missing teeth (14).

Two articles in this collection address Healthy People 2030's oral health objective 8 by using data from predominantly rural states, Alabama and Georgia. In "Visualizing County-Level Data to Target Dental Safety-Net Programs for Children," Hamilton et al used geographic information systems (GIS) to showcase visually how dental safety-net clinics in Georgia were placed in the areas of highest need (15). Their methodology can be used by others to help assess whether dental public health resources are allocated in places of greatest need, that is, where the prevalence of untreated caries is high. The data used to generate the maps are publicly available for all states and, thus, could enable any jurisdiction to replicate the assessment.

In "Visualizing Potential Effects of Dentist Retirements on Accessibility to Dental Care Among Children in Alabama," Samsel et al also used GIS to visualize the effect of dentist retirements on access to oral health care, a topic not previously studied (16). These authors measured the spatial accessibility of a licensed dentist among young people (children, adolescents, and young adults aged ≤20). Rates of access to dentists in this population were higher in urban areas (1.3 providers per 1,000 young people) than in rural areas (0.8 providers per 1,000 young people). The effect of dentist retirements on accessibility to dental care in rural areas was greater than in urban areas. Although the results pertain to Alabama, any state can use these methods to study the effect of dentist retirements on accessibility to care. Strategies to make it easier to get dental care are critical for better oral health and overall health outcomes.

Healthy People 2030 oral health objectives 1 and 2 aim to reduce the proportion of children and adolescents with lifetime tooth decay and children and adolescents with active and untreated tooth decay, respectively. Disparities in access to dental services directly relate to disparities in the prevalence of children and adolescents with these problems. A Centers for Disease Control and Prevention report in 2019 highlighted many of these disparities, showing, for example, that the prevalence of caries and untreated tooth decay among African American and Mexican American children, adolescents, and young adults aged 2 to 19 years was up to 2 to 3 times higher than among their non-Hispanic White counterparts. That report also showed that children and adolescents living below 200% of the federal poverty level had almost double the prevalence of caries and untreated decay as children and adolescents living at or above 200% of the federal poverty level (17).

Healthy People 2030 objective 8 is also relevant in "Racial/Ethnic Disparities Among US Children and Adolescents in Use of Dental Care" (18). Robison et al examined changes in racial/ethnic disparities in annual dental care use among children and adolescents aged 2 to 17 years from 2001 to 2016. With a sample of 132,763 children and adolescents, the researchers found that the gap between dental care use among Hispanic or Latino, Asian, and Black/African American children and dental care use among non-Hispanic White children had narrowed significantly from 2001 to 2016. The disparity in the prevalence of dental care use between non-Hispanic White children and adolescents and Asian children and adolescents declined 75%, from an 18.8 percentage-point difference in 2001 to a 4.7 percentage-point difference in 2016. Among Hispanic/Latino children and adolescents, this disparity declined by 61% (from a 23.6 percentage-point difference to a 9.1 percentage-point difference), and among Black/African American children and adolescents, it declined by 38% (from a 25.4 percentage-point difference to a 15.7 percentage-point difference). By income level, children and adolescents from low-income households of all races/ethnicities showed the most marked increase in use of dental care, increasing by 18% from the 2001–2005 data cycle to the 2011–2016 data cycle. Furthermore, use of dental services among Hispanic/Latino and Asian children and adolescents from low-income households was similar to use among non-Hispanic White children and adolescents but was well below that of children and adolescents from middle- and high-income households, and disparities persisted for Black/African American children and adolescents at all income levels.

Healthy People 2030 oral health objective 9 is to increase the proportion of young people from low-income households who have a preventive care dental visit. In "Oral Health Behaviors in Very Young Children in Low-Income Urban Areas in Chicago, Illinois, 2018–2019," Martin et al analyzed the oral health behaviors of children from low-income households who were aged 3 years or younger, an age group not studied often for oral health behaviors (19). Important parental and caregiver behaviors included bringing young children to their dental visits and supervising children's oral hygiene at home. Using caregiver-reported data from 420 families in Cook County, Illinois, and objectively measured plaque index scores, researchers identified correlations between infant and toddler risk factors for oral disease and the oral health of their caregivers. Caregivers who brush their teeth were more likely to brush their children's teeth as well, and having additional caregivers assist with brushing the child's teeth was associated with both higher brushing frequency and lower plaque scores. This study points to the need to evaluate the family support structure when assessing risk factors for oral disease in young children, and for oral health professionals to promote additional caregiver and family support in implementing an oral health regimen among infants and toddlers. Creative interventions that facilitate behavior change in parents may help lower the risk for development of dental caries in children.

Another article, "Does Preventive Care Reduce Severe Pediatric Dental Caries?" also examined preventive dental care in children from low-income households (20). Lee et al compared the effect of increased Medicaid reimbursements for preventive dental care on use of tertiary oral health services (caries-related surgery, sedation, and emergency department visits) in children aged 9 years or younger in Texas and Florida. The observational study used Medicaid enrollment and claims filed in 2007 and 2011–2012. Linear regression models estimated the outcomes of preventive care dental visits, caries-related sedations, caries-related emergency department visits, and caries-related surgeries. Examining records of 7,748,850 children, the authors found that after Medicaid reform to increase reimbursement for dental care providers in Texas, preventive care dental visits increased by 11.4%, caries-related surgeries increased by 0.01%, caries-related sedation increased by 1.7%, and caries-related emergency department visits decreased by 0.3%. The authors concluded that increasing provider reimbursements was effective in increasing access to preventive dental care for Medicaid-enrolled children, and although increased prevention resulted in increased procedures to treat caries, the decline in caries-related emergency department visits attributed to prevention quantified the gap in previously unmet need.

Preventive dental care can significantly improve oral health in children. One preventive strategy is the placement of dental sealants, and Healthy People 2030 oral health objective 10 is to increase the proportion of children and adolescents who receive dental sealants on 1 or more of their primary or permanent molars. The chewing surfaces of the molars, known as the occlusal surfaces, are the most susceptible to decay. Among children aged 6 to 11 years with at least 1 decayed tooth, 90% of the disease is located in the first molars; among children and adolescents aged 12 to 17, 79% of disease is located the first and second molars (21). The deep pits and fissures on these surfaces are difficult to clean; dental sealants are directly applied to these surfaces to protect them (22).

In “Awareness Among US Adults of Dental Sealants for Caries Prevention,” Junger et al used data from a national consumer survey to describe the lack of knowledge about dental sealants among adults and among a subgroup of adult parents of children aged 18 years or younger (23). Only about half of the respondents in each group could correctly answer a question about the purpose of dental sealants. Parents (55%) were slightly more likely than adults overall (46%) to have answered the question correctly. Disparities in sealant knowledge mirrored disparities in the use of sealants and the prevalence of caries among children: parents of children in the most disproportionately affected groups — families with less education, families with low income, and members of racial/ethnic minority populations — were less likely to be aware of the benefits of dental sealants. The authors recommend collaborative health promotion and educational efforts that draw on various groups of people, including oral health professionals, pediatricians, school nurses, and teachers. School sealant programs help reach children at high risk of caries, and these programs should be expanded.

A common theme of many of the articles in this PCD collection is the effect of access to oral health services, especially preventive services, on the prevalence of oral diseases. Access to the oral health system is the foundation for all Healthy People 2030 oral health objectives. Many oral health disparities among the populations of interest in this collection could be exacerbated by the COVID-19 pandemic. In their commentary, “Oral Health and COVID-19: Increasing the Need for Prevention and Access,” Brian and Weintraub describe disparities and opportunities in the dental community that have arisen as a result of the pandemic (24). Many oral health objectives are relevant to their discussion. Early in the pandemic, closure of dental practices except for emergencies excluded routine care and prevention. Brian and Weintraub discuss the importance of oral health during COVID-19; chronic disease disparities; access to care limitations; increased risk of infection among dental providers through use of aerosol-generating devices (ie, dental handpieces, ultrasonic scalers); opportunities for change, including the use of nonaerosol-producing dental devices, materials and procedures; increasing nonsurgical prevention and management; enhancing Medicaid reimbursement, especially the expansion of adult Medicaid dental benefits in many states where it is limited or nonexistent; easing dental workforce restrictions; and advancing teledentistry to address gaps and increase access to preventive care. One of the many negative effects of COVID-19 is that National Health and Nutrition Examination Survey activities were paused out of an abundance of caution to protect participants, survey staff members, and communities (25). The need for ongoing national surveillance of oral health and disease trends is critical because the pandemic affects access to care and care-seeking behaviors, especially in populations with preexisting health disparities.

Although this collection of articles in PCD does not address all 11 Healthy People 2030 oral health objectives, it does touch on cross-cutting issues such as access to dental care, oral health disparities and inequities, and prevention of dental disease. Oral health objectives not addressed in this collection are to reduce the proportion of adults with active or untreated decay (objective 3), to reduce the proportion of older adults with untreated root surface decay (objective 4), to reduce the proportion of adults aged 45 or older who have lost all their teeth (objective 5), to increase the proportion of oral and pharyngeal cancers detected at the earliest stage (objective 7), to increase the proportion of people whose water systems have the recommended amount of fluoride (objective 11), and to increase number of states, plus the District of

Columbia, with oral and craniofacial health surveillance systems (objective D1). Objectives developed by other Healthy People 2030 work groups also address oral health–related areas, such increasing the proportion of people with dental insurance (Access to Health Services [AHS] objective AHS-02]), reducing the proportion of people who are unable to obtain or are delayed in obtaining necessary dental care (objective AHS-05), and reducing the consumption of calories from added sugars by persons aged 2 years or older (Nutrition and Weight Status objective 10).

The second Surgeon General's Report on Oral Health is expected to be released in 2021. The new report will describe key issues that currently affect oral health, identify challenges and opportunities that have emerged since publication of the first report, articulate a vision for the future, and call upon all Americans to take action. Its predecessor was published in 2000, with the message that oral health means much more than healthy teeth and is integral to the overall health and well-being of the US population (1). Indeed, this message continues to resonate today, because a person cannot have good overall health without having good oral health. This PCD collection of oral health articles and its underlying foundation of the Healthy People 2030 oral health objectives provides us with a roadmap for improving oral health and, thus, overall health in the United States. The articles provide a snapshot of why oral health needs to be elevated as a policy priority by being included and integrated into discussions and policy decisions about health. Thus, addressing the social, behavioral, and environmental determinants of health as part of oral health care offers a new approach to prevention and treatment (26).

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SYSTEMATIC REVIEW

Current Knowledge on Correlations Between Highly Prevalent Dental Conditions and Chronic Diseases: An Umbrella Review

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PEER REVIEWED

Summary

What is already known on this topic?

Substantive evidence supports a correlation between dental conditions and chronic systemic diseases.

What is added by this report?

We provide an overview of systematic reviews reporting on correlations between dental conditions and chronic diseases with an assessment of the evidence and extent of correlation.

What are the implications for public health practice?

There is a need for more awareness about 1) existing evidence on correlations between dental conditions and chronic systemic diseases, 2) potential opportunities for better medical–dental integration in the delivery of care, and 3) the need for future research about potentially causal links between dental conditions and chronic diseases.

Abstract

Introduction

Studies have investigated the relationships between chronic systemic and dental conditions, but it remains unclear how such knowledge can be used in clinical practice. In this article, we provide an overview of existing systematic reviews, identifying and evaluating the most frequently reported dental–chronic disease correlations and common risk factors.

Methods

We conducted a systematic review of existing systematic reviews (umbrella review) published between 1995 and 2017 and indexed in 4 databases. We focused on the 3 most prevalent dental conditions and 10 chronic systemic diseases with the highest burden of disease in Germany. Two independent reviewers assessed all articles for eligibility and methodologic quality using the AMSTAR criteria and extracted data from the included studies.

Results

Of the initially identified 1,249 systematic reviews, 32 were included for qualitative synthesis. The dental condition with most frequently observed correlations to chronic systemic diseases was periodontitis. The chronic systemic disease with the most frequently observed correlations with a dental condition was type 2 diabetes mellitus (T2DM). Most dental–chronic disease correlations were found between periodontitis and T2DM and periodontitis and cardiovascular disease. Frequently reported common risk factors were smoking, age, sex, and overweight. Using the AMSTAR criteria, 2 studies were assessed as low quality, 26 studies as moderate quality, and 4 studies as high quality.

Conclusion

The quality of included systematic reviews was heterogeneous. The most frequently reported correlations were found for periodontitis with T2DM and for periodontitis with cardiovascular disease. However, the strength of evidence for these and other disease correlations is limited, and the evidence to assess the causality of these disease correlations remains unclear. Future research should focus on the causality of disease links in order to provide more decisive evidence with respect to the design of intersectoral care processes.

Introduction

Human life expectancy has been increasing for many years (1). However, as life expectancy increases, so does the prevalence of chronic diseases within the population (2). Treatment of chronic diseases frequently takes place in highly specialized disciplines (3). However, chronic conditions often emerge, develop, and occur in parallel with other illnesses (4), and with each chronic condition life expectancy again decreases (5). Because of the high likelihood of patients with chronic conditions developing additional diseases, scientific study of the correlations between diseases is necessary.

The medical scope of such correlations often exceeds the boundaries of medical disciplines. An example of this is the correlation between dental conditions and other noncommunicable diseases, which have been investigated in many scientific publications and in previous empirical literature (6). In the past decades, however, dental care and primary medical care have largely evolved separately. Addressing the links between dental and other chronic conditions can improve health care and prevention of chronic conditions (7), in particular identifying appropriate and necessary areas for inter-professional cooperation between general medical and dental professionals (7).

Many systematic reviews (SRs) to estimate the extent of dental–chronic disease correlations have been conducted for specific dental conditions and chronic systemic diseases, but a systematic overview to provide information about the extent to which there is decisive evidence with respect to the design of intersectoral care processes does not exist so far. The aim of this study was to conduct an umbrella review to provide an overview of the most recent evidence from SRs about interdependencies between dental conditions and chronic systemic diseases. The underlying research question was, "What is the current state of knowledge concerning possible relationships between dental conditions and chronic systemic diseases?" The umbrella review aimed to identify potential intervention points for inter-professional cooperation, including evidence on 1) correlations between highly prevalent dental conditions and chronic systemic diseases, 2) common risk factors, and 3) how dental conditions cause chronic diseases and vice versa.

Methods

This study was conducted as part of a project aiming to improve intersectoral care between dentists and general practitioners (8). The results of this literature review will be combined with an analysis of claims data and patient reported measures into a decision support system (DSS). The DSS targets links between dental conditions and chronic systemic diseases managed in dental and primary care in Germany. The umbrella review focused on the chronic systemic diseases and dental conditions with the highest prevalence in Germany (9). The prevalence of these conditions in Germany is comparable to that of other Western European countries (10).

Data sources

The scope of the review was defined using the PICO structure (11). The target population was defined as patients with a combination of 1) a chronic systemic disease and 2) 1 of the 3 dental conditions with the highest burden of disease: periodontitis (*International Classification of Diseases, 10th Revision* [ICD-10] K05), dental caries (ICD-10: K02.0), and tooth loss (ICD-10: K08.1) (12,13). There were no restrictions with respect to the type of (comparative) interventions or the (dental) health outcomes considered.

The search strategy was jointly developed by the authors (M.S., S.L., C.H., M.vdZ.) and sense-checked by 2 experts in dental and primary care and pharmacology. A librarian specializing in SRs reviewed the search strategy. For dental conditions the search terms were adjusted from the study by Haag et al (14).

The applied search strategy we used for PubMed is as follows:

("Dental Caries"[Mesh] OR "Periodontal Diseases"[Mesh] OR "Mouth, Edentulous"[Mesh]
OR ((tooth[tiab] OR teeth[tiab] OR dental) AND (caries[tiab] OR carious[tiab] OR decay*[tiab] OR lesion*[tiab]))
OR "root caries"[tiab] OR "root decay"[tiab] OR "DMF Index"[tiab] OR "DMFT"[tiab] OR "DMFS"[tiab]
OR periodontal disease*[tiab] OR periodontitis[tiab] OR periodontal pocket*[tiab] OR periodontology[tiab]
OR "periodontal therapy"[tiab] OR periodontal treatment*[tiab] OR "periodontics"[tiab] OR "tooth loss"[tiab]
OR "number of teeth"[tiab] OR "shortened dental arch"[tiab] OR "functional dentition"[tiab] OR edentul*[tiab]
OR "missing teeth"[tiab] OR "missing tooth"[tiab] OR prosthodontics[tiab])
AND ("Chronic Disease"[Mesh] OR "Disease Progression"[Mesh] OR "Cardiovascular Diseases"[Mesh]
OR "Diabetes Mellitus"[Mesh] OR "Lung Diseases, Obstructive"[Mesh] OR "Pneumonia"[Mesh]
OR "Arthritis, Rheumatoid"[Mesh] OR ((disease[tiab] OR diseases[tiab] OR condition[tiab]
OR illness[tiab] OR ill[tiab] OR diseased[tiab]) AND (chronic[tiab] OR chronically[tiab]
OR systemic[tiab] OR cardiovascular[tiab] OR cerebrovascular[tiab])) OR "diabetes mellitus"[tiab]

OR "glycemic control"[tiab] OR diabetes[tiab] OR hyperglycemia[tiab] OR
stroke[tiab] OR "cerebral ischemia"[tiab]
OR bronchitis[tiab] OR "pulmonary disease"[tiab] OR pneumonia[tiab] OR
"rheumatoid arthritis"[tiab] OR Aspiration[tiab])
AND systematic[sb]
NOT ("animals"[Mesh] NOT "humans"[Mesh])

The search strategy was adapted for the searches in Embase, Cochrane, and LILACS. More details can be found here: https://doi.org/10.11588/data/ORTPJN.

Because of the multiple existing definitions for periodontitis, the search strategy was developed liberally to include a broad definition of periodontal disease. In addition, chronic diseases were addressed under various definitions (15). We used the term to refer to the definition by the World Health Organization (WHO): "Noncommunicable diseases . . . also known as chronic diseases, are not passed from person to person. They are of long duration and generally slow progression" (16). To further refine the search and include results on specific chronic diseases, diabetes (ICD-10: E10-E14), cardiovascular disease (CVD) (ICD-10: I20-I25), and chronic respiratory diseases (ICD-10: J40-J47) were prioritized as highly prevalent chronic conditions (9). Additionally (in their initial and moderate phase), they can be primarily detected and comprehensively managed in primary care.

A comprehensive literature search was performed on the PubMed, Embase, Cochrane, and LILACS databases in October 2017, including articles published up to 2017. EndNote version X8.1 was used for reference management (Clarivate Analytics). Duplicate references were excluded before article assessment. Two reviewers (M.S. and M.vdZ.) screened the title and abstract of all articles independently, excluding all records that did not meet the inclusion criteria. Based on the results of title and abstract screening, the inclusion criteria for the full-text screening were extended for the 10 chronic systemic diseases with the highest burden of disease. Those were defined as diseases that cause the most combined death and disability in Germany (9): ischemic heart disease, low back and neck pain, sensory organ diseases, cerebrovascular disease, lung cancer, Alzheimer disease, skin diseases, diabetes, chronic obstructive pulmonary disease (COPD), and migraine. The full text for all remaining articles was retrieved where available. In a second round, the articles were assessed by full text, using the adapted inclusion and exclusion criteria. Differences in assessment were discussed by the 2 reviewers, and in case of disagreements, a third reviewer (S.L.) made the final decision to include or exclude the article. The data from the remaining full-text articles were then extracted and the quality of the articles assessed.

Study selection

After the database searches were conducted, all potential articles were aggregated in EndNote. The articles were screened by title and abstract for relevance. To ascertain interrater reliability, a calibration between the reviewers was conducted. The decision for inclusion or exclusion by both reviewers was compared for the first 100 screened articles and agreement was calculated by means of the Kappa value (17). Discrepancies were solved by an open discussion between the reviewers. If no consent could be reached, the third reviewer (S.L.) made the final decision.

Study inclusion criteria were 1) must be published in English; 2) must be an SR, a meta-analysis, or an umbrella review; 3) must be on patients with one of the predefined dental conditions (periodontitis, dental caries, or tooth loss) and a chronic systemic disease; and 4) must report on the link between the diseases. Studies were excluded if they 1) did not meet the inclusion criteria; 2) reported exclusively on children or animals; 3) did not report precisely the underlying search strategy; 4) contained no clear criteria for inclusion and exclusion of articles; 5) had not searched multiple databases; 6) did not include original studies; 7) reported on the same study as another included systematic review; 8) were included in another study that was already included; and 9) reported exclusively on a) a confounder and a dental condition but not a chronic systemic disease or b) a confounder and a chronic systemic disease but not a dental condition. The complete list of articles excluded in the full text screening, with reason for exclusion, can be found here: https://doi.org/10.11588/data/ORTPJN.

Data extraction

The data from the articles included for qualitative synthesis were independently extracted by the 2 reviewers by using a standardized data collection form. Quantitative synthesis was not possible, because the included systematic reviews reported on correlations between various combinations of diseases. The 2 reviewers independently assessed the methodologic quality of the identified studies using the AMSTAR 11-point checklist (18), a measurement tool for assessing the quality of reporting of systematic reviews. Studies were designated as low quality if they met 0 to 3 criteria, moderate quality if they met 4 to 7 criteria, and high quality if they met 8 to 10 criteria. Discrepancies were discussed between the reviewers until agreement was reached on all items (Table 1). After this, the remaining articles were assessed.

Results

The search strategy was applied on the literature databases PubMed, Embase, Cochrane, and LILACS. We initially identified 1,249 articles; 992 remained after duplicates were removed.

Based on ratings of the 100 first-screened articles, there was good interrater reliability between the 2 reviewers (κ = 0.74). During title and abstract screening, 725 articles were excluded. The remaining 267 articles were evaluated for eligibility in a full-text assessment, and 235 were excluded (Figure 1). Thirty-two studies met the inclusion criteria and were included in the qualitative synthesis (Table 2).

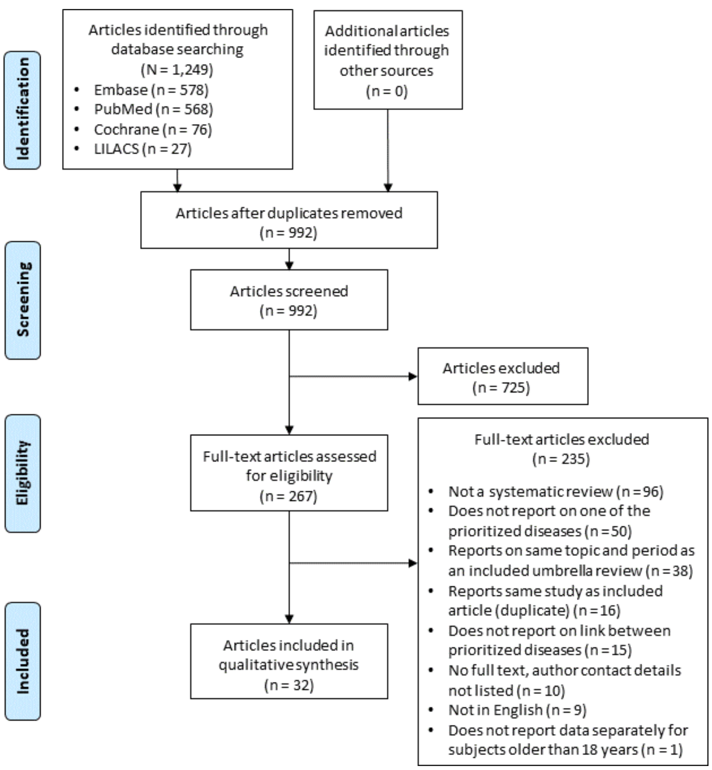

Figure 1. Flow diagram showing exclusion and inclusion process during the literature review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) system. Articles were screened for an umbrella review of systematic reviews published between 1995 and 2017 on correlation between prevalent dental conditions and chronic diseases in Germany.

Methodologic quality of systematic reviews

The quality of all SRs included in the qualitative synthesis was assessed using the 11-point AMSTAR checklist (Table 1). In our assessment, SRs met between 3 and 10 of the possible 11 criteria (median = 6). No review complied with all 11 points of the tool.

Criterion 3 ("Was a comprehensive literature search performed?" [n = 32]) and criterion 6 ("Were the characteristics of the included studies provided?" [n = 31]) were met by nearly every SR. Criterion 11 ("Was the conflict of interest included?" [n = 5]) was rarely met. Criterion 7 ("Was the scientific quality of the included studies assessed and documented?" [n = 23]) and criterion 10 ("Was the likelihood of publication bias assessed?" [n = 12]) were fulfilled by many of the studies. Two studies were determined to be low quality, 26 studies were moderate quality, and 4 studies were high quality.

Characteristics of included SRs

The primary studies included in the SRs were conducted between 1995 (24) and May 2017 (21) (Table 2). The included SRs varied in diverse aspects. Multiple primary studies, including randomized controlled trials (RCTs) (14,15), case-control studies (CCSs) (22,23), cross-sectional studies (22,23), cohort studies (22), clinical trials (25), observational studies (32), mixed-method studies (32), pilot studies (41), and population surveys (41) were examined. The primary studies differed by study population, from 303 participants in an RCT (37) to 1,025,340 subjects in a CCS (39). They also differed by location; studies were conducted in Europe (Austria, Belgium, France, Germany, Greece, Italy, Norway, Poland, Portugal, Spain, Sweden), North America (United States), South America (Brazil), and Asia (China, Iran, Japan, Saudi Arabia, South Korea, Taiwan).

Fifteen different disease combinations were examined in the included SRs (Table 3). Multiple studies reported on common risk factors that can have a progressive effect on dental and chronic systemic conditions. The most frequently mentioned were smoking (21,23,35,36,39,41,43,44,46–48,50), age (23,35,36,39,41,43,47), sex (35,36,39,41,43), and body mass index (BMI) or overweight (35,36,39,44,46).

In addition to reporting on common risk factors, multiple studies reported on chronic systemic diseases increasing the risk of developing a dental condition and vice versa. D'Aiuto et al (26) reported strong evidence for T2DM being a risk factor for periodontal diseases. Leng et al (36) reported that patients with a periodontal disease have a significantly increased risk for developing coronary heart disease, and patients with periodontitis have an elevated risk for myocardial infarction (47). Multiple studies reported on associations between cerebrovascular diseases (eg, stroke) and dental conditions. For example, Lafon et al (33) reported that the risk of ischemic or hemorrhagic stroke was higher for people with periodontitis (estimated adjusted risk, 1.63 [95% confidence interval (CI),1.25–2.00]) and that tooth loss is a significant risk factor for stroke (estimated adjusted risk, 1.39 [95% CI, 1.13–1.65]). Likewise, Leira et al (35) found that the risk of cerebral ischemia was higher in subjects with periodontitis (relative risk, 2.88 [95% CI, 1.53–5.41]), suggesting a positive association between ischemic stroke and the prevalence of periodontitis. Another study reported that periodontal disease significantly increases the risk of COPD (49).

Summary of the systematic reviews

The studies included in the analysis reported on 107 correlations between dental conditions and chronic systemic diseases. Among the 32 SRs included in the qualitative synthesis, 6 were umbrella reviews. These 6 umbrella reviews incorporated 98 SRs, but 2 of the umbrella reviews investigated multiple disease correlations, not all of which met the inclusion criteria of this review. Therefore, in the analysis of disease correlations, 107 SRs were included.

The most frequently observed dental condition that was correlated with chronic systemic diseases was periodontitis (n = 88). Links between tooth loss and chronic systemic diseases (n = 11) and dental caries with chronic systemic diseases (n = 8) were observed less often.

In terms of chronic systemic diseases, most correlations with dental conditions were identified for T2DM (n = 51) and CVD (n = 41). Less frequently observed were correlations with cerebrovascular disease (n = 8), COPD (n = 3), dementia (n = 2), psoriasis (n = 1), and lung cancer (n = 1).

Most disease correlations were found for periodontitis with T2DM (n = 46) (19–21,24,26,29,30,38,40) and periodontitis with CVD (n = 33) (23,27,28,31,34,36,37,39,41–44,47,48). This was followed by SRs indicating correlations of tooth loss with CVD (n = 6) (28), periodontitis with cerebrovascular disease (n = 4) (25,28,32,35), and dental caries with T2DM (n = 4) (26). For the remaining diseases, between 0 and 2 correlations were observed.

The results of the data extraction showed that the included SRs indicated that there was an absence of causal evidence between the reported diseases. This was reported for correlations of CVD with periodontitis (42,48) and cerebrovascular disease with dental caries (29). None of the included SRs, which reported on links between periodontitis and diabetes mellitus, reported to have specifically investigated about causal inference concerning the examined diseases (Figure 2).

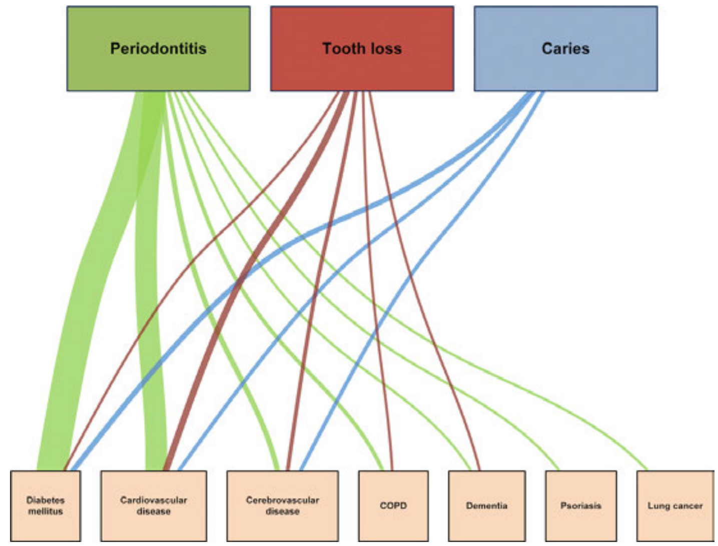

Figure 2. Illustration of the number of identified systematic reviews that showed disease correlations, umbrella review of systematic reviews published between 1995 and 2017 on correlation between prevalent dental conditions and chronic diseases in Germany. Width of lines illustrates the number of systematic reviews that report on the disease combinations. Abbreviation: COPD, chronic obstructive pulmonary disease.

Discussion

In our umbrella review, we found that of all the interrelationships between dental conditions and chronic systemic diseases described in the included systematic reviews, periodontitis was the dental condition with the most reported correlations to chronic systemic diseases and T2DM was the chronic condition for which most correlations to dental conditions were found. The most frequently reported correlations were 1) periodontitis with T2DM and 2) periodontitis with CVD.

The identified correlations should be carefully considered in the care provided to multimorbid patients with combinations of dental conditions and chronic systemic diseases. These patients may potentially benefit from an increased sensibility and awareness of practitioners for disease correlations, the potential for earlier diagnosis, and better coordination of the attending physicians. In this context, our findings can support practitioners by highlighting correlating diseases through common risk factors (eg, smoking) and disease indicators (eg, high hemoglobin A1c). For example, dentists treating patients with difficulties in controlling chronic periodontitis should consider the possibility of correlating chronic systemic conditions that worsen recovery and accelerate recurrence, such as T2DM. By coordinating the treatment with the attending physician or diabetes specialist, treatment and control of both correlating diseases can be improved. Better integration of diabetes and periodontal care has also been highlighted in international medical guidelines (52,53). Further improvement of intersectoral care necessitates that both dentist and general practitioner are sufficiently aware of existing correlations between dental conditions and chronic systemic diseases and how these correlations may influence treatments. For the treatment of diseases that are linked but treated by separate groups of health care professionals, communication, information exchange, and decision support can contribute to greater quality of care. At the same time, unnecessary medical interventions should be avoided if there is no solid evidence base supporting a possible benefit for the patient.

As for the correlation of periodontitis with T2DM, our findings indicate substantial evidence. In addition, the included studies suggest that the treatment of periodontitis may improve the glycemic regulation of T2DM patients (19,20,24,26,29,30). Although the association between periodontitis and T2DM was most frequently studied among the included SRs, the SRs did not report to have specifically investigated about causal inference concerning the relationship between both diseases. Conversely, all SRs that investigated causality between dental conditions and other chronic diseases reported congruently about insufficient evidence to determine causality. As a result, we could not ultimately confirm that the identified relationships are causal.

For 2 disease correlations, periodontitis with T2DM and periodontitis with CVD, the existence of a correlation could be confirmed by multiple SRs. In case of other disease correlations (tooth loss with CVD, dental caries with DM, and periodontitis with cerebrovascular disease), evidence was present for only a few reviews (n = 4–6). There was evidence of a correlation for the remaining conditions, although it was limited (n = 1–2), and the existing evidence is still unclear. Regardless of the level of evidence for any of the correlations, the conclusiveness of currently existing evidence often remains vague. In some cases, studies contradicted or differed from each other with regard to the assessment.

When assessing potential causal pathways between dental conditions and chronic systemic diseases, common risk factors play an important role. They can have a direct or indirect impact on multiple disease entities. The SRs frequently reported common risk factors for dental and chronic systemic conditions, including smoking, age, sex, and BMI/overweight. A study by Sheiham and Watt (54) reported additionally about diet, hygiene, alcohol use, stress, and trauma as important common risk factors. Because common risk factors increase the possibility of further diseases in chronically ill patients, they can be used as indicators for the development or presence of another related disease. Raising health care practitioners' awareness of this issue may improve the prevention and early detection of comorbidities for chronically ill patients. In the context of intersectoral patient care, common risk factors should be considered to identify patients who should be referred to another specialist to verify a suspected comorbidity. Patients with comorbidities in particular could benefit from a better cooperation and coordination among the attending practitioners in various disciplines (7).

The study has several limitations. First, because of the heterogeneous quality of the included SRs, the evidence on links between chronic systemic and dental conditions should be interpreted with caution. However, to counteract the risk of bias by including heterogeneous and low-quality SRs, we assessed the quality of the reviews with the AMSTAR (18) tool, and the evaluation showed that the heterogeneity was moderate: 2 reviews were low quality, 26 were moderate quality, and 4 were high quality. In addition, the large number of included studies necessitated a more general overview than would be possible in a study focusing on specific diseases. However, this umbrella review was designed to summarize existing knowledge for links between dental conditions and chronic systemic diseases from a broad perspective. Because we used a broad search strategy, our search may not have identified studies using definitions that are not common in literature. In order not to miss any relevant SR or disease in spite of the broad search strategy, we included the most commonly used terms for each of the focused diseases, including key terms and categorizations used in each database. Medical terms that are often hidden under various classifications and definitions (eg, periodontitis [55]: chronic periodontitis, periodontosis, aggressive periodontitis, periodontal disease) were included, and the search was checked by 2 experts to ensure that all relevant terms were included.

Second, the included SRs documented various disease correlations, including different types of studies, populations, interventions, and outcomes. This, and differences in the research questions of the included SRs, restricted the comparability of our results. This showcases a high degree of heterogeneity in the literature on chronic-dental disease links. For example, numerous definitions and biomarkers for periodontitis have been used in the literature, and this may affect any overview of studies reporting on correlations between periodontal and chronic systemic diseases. Third, given the variety of chronic systemic diseases and the specific context for which this study was conducted, we prioritized chronic systemic diseases according to the prevalence of disease in Germany. Therefore, our findings may not be generalizable to other settings or contexts. We set this priority because the ultimate objective of this project (8) is to apply our findings to German routine care and to improve multimorbid patient care by general practitioners and dentists. But because the burden of disease in Germany is similar to that of other Western European countries (10) and because the consideration and treatment of patients with dental conditions and general diseases is analogous worldwide, our findings are more broadly transferable.

Despite the limitations, to our knowledge our study is the first that provides a systematic and comprehensive overview and quality assessment of the evidence on correlations between highly prevalent dental conditions and chronic diseases, as reported in previously published SRs. Given the worldwide high prevalence and incidence of dental conditions and increasing co-occurrence with chronic systemic diseases, our findings are relevant and raise awareness for potential opportunities of better integrating medical and dental care.

Future research direction

The presented overview of correlations between dental conditions and chronic systemic diseases could be used as a guide to prioritize future studies on disease interdependencies, with particular attention being given to making causal inference. Focus should be set on the identification of the best-substantiated correlations and gaps in the study of disease correlations. To reduce uncertainties and to adequately raise awareness for disease correlations, it is important to provide health care practitioners and patients with information about the extent to which there is decisive evidence with respect to (potentially) causal disease links. For this purpose, clinical guidelines for intersectoral care could improve patient care. Yet, in the absence of robust and decisive evidence, guideline development continues to be highly challenging. In addition, even when guidelines can be developed, serious concerns have been raised about the persistence of "implementation gaps" (7,56). To promote the development of intersectoral guidelines and provide practitioners with fundamental knowledge about disease correlations, research should focus on the underlying causes and extent of disease relationships. Furthermore, it should be assessed how and to what extent interventions can support the treatment and prevention of correlating diseases. Research into the causality underlying disease correlations is an important basis for guiding interdisciplinary collaboration and development of guidelines.

Not least, another promising opportunity to improve the translation from knowledge into action is the development of electronic decision support systems, such as the initiatives conducted by the Agency for Healthcare Research and Quality (57). Thereby, to promote joint considerations of practitioners who treat patients with comorbid conditions, it is also important to decipher the role of common risk factors, which may serve as early markers to initiate pathways of intersectoral care.

Conclusion

This review contributes to the literature by comprehensively summarizing the evidence, identifying and evaluating the most frequently reported disease correlations and common risk factors, and aggregating the information to provide information about the extent to which there is decisive evidence with respect to the design of intersectoral care processes. The most frequently reported correlations were found for periodontitis with diabetes mellitus type 2 and for periodontitis with cardiovascular disease. Associated common risk factors were smoking, age, sex and overweight. Correlations between dental and chronic systemic diseases have frequently been reported but the existing evidence remains unclear with respect to causal inference. Future research should therefore focus on the causality of disease links in order to provide more decisive evidence with respect to the design of intersectoral care processes. More decisive evidence would also be relevant for future prioritization in the design of intersectoral care processes and the development of electronic decision support systems.

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Tables

Table 1. Results of the Quality Assessment for Included Systematic Reviews Using AMSTAR Checklist, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study (year)	1. A Priori Design	2. Duplicate Selection	3. Literature Search	4. Status of Publication	5. List of Studies	6. Characteristics of Studies	7. Quality of Studies	8. Scientific Quality	9. Appropriate Methods	10. Likelihood of Bias	11. Conflict of Interest	Score
Abduljabbar, Javed et al (2017) (19)	0	1	1	0	1	1	1	1	1	0	0	7
Abduljabbar, Vohra et al (2017) (20)	1	1	1	1	1	1	1	1	1	0	0	9
Al-Hamoudi (2017) (21)	0	0	1	0	0	1	1	0	1	0	0	4
Azarpazhooh and Leake (2006) (22)	0	0	1	0	1	1	1	0	0	0	0	4
Batista et al (2011) (23)	0	0	1	1	1	1	0	0	0	0	0	4
Botero et al (2016) (24)	1	1	1	1	0	1	1	1	1	1	0	9
Dai et al (2015) (25)	0	1	1	0	1	1	1	0	1	1	0	7
D'Aiuto et al (2017) (26)	0	1	1	0	0	1	0	0	1	0	0	4
D'Aiuto et al (2013) (27)	0	1	1	0	0	1	1	0	0	0	1	5
Dietrich et al (2017) (28)	0	0	1	0	0	1	1	0	0	0	0	3
Faggion et al (2016) (29)	0	1	1	0	1	1	1	1	1	1	1	9
Hasuike et al (2017) (30)	1	0	1	0	0	1	1	1	1	0	1	7
Kelly et al (2013) (31)	0	1	1	0	1	0	1	1	1	0	1	7
Kothari et al (2017) (32)	0	1	1	1	0	1	0	0	1	0	0	5
Lafon et al (2014) (33)	0	1	1	0	0	1	1	0	1	0	0	5
Lam et al (2011) (34)	0	1	1	0	0	1	0	0	0	0	0	3
Leira et al (2017) (35)	1	1	1	0	0	1	1	1	1	0	0	7
Leng et al (2015) (36)	1	0	1	0	0	1	0	0	1	1	0	5
Li et al (2014) (37)	1	1	1	1	1	1	1	1	0	1	1	10
Lira et al (2017) (38)	0	1	1	1	1	1	1	0	1	0	0	7
Martin-Cabezas et al (2016) (39)	0	1	1	0	0	1	0	0	1	0	0	4
Mauri-Obradors et al (2017) (40)	0	1	1	0	0	1	1	0	0	0	0	4
Orlandi et al (2014) (41)	0	1	1	1	0	1	1	0	1	1	0	7
Sanchez et al (2017) (42)	0	0	1	1	0	1	1	0	0	0	0	4
Schmitt et al (2015) (43)	0	1	1	1	1	1	1	0	1	0	0	7
Teeuw et al (2014) (44)	0	0	1	0	0	1	1	0	1	1	0	5
Tonsekar et al (2017) (45)	0	1	1	0	1	1	1	1	0	0	0	6
Ungprasert et al (2017) (46)	0	1	1	0	0	1	1	1	1	1	0	7

Abbreviation: AMSTAR, Assessing the Methodological Quality of Systematic Reviews.

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Table 1. Results of the Quality Assessment for Included Systematic Reviews Using AMSTAR Checklist, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study (year)	1. A Priori Design	2. Duplicate Selection	3. Literature Search	4. Status of Publication	5. List of Studies	6. Characteristics of Studies	7. Quality of Studies	8. Scientific Quality	9. Appropriate Methods	10. Likelihood of Bias	11. Conflict of Interest	Score
Xu et al (2017) (47)	0	1	1	0	0	1	1	0	1	1	0	6
Zeng, Leng et al (2016) (48)	0	1	1	0	1	1	0	0	1	1	0	6
Zeng et al (2012) (49)	0	1	1	0	0	1	0	0	1	1	0	5
Zeng, Xia et al (2016) (50)	0	1	1	0	1	1	0	0	1	1	0	6

Abbreviation: AMSTAR, Assessing the Methodological Quality of Systematic Reviews.

Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
Abdul-jabbar, Javed et al (2017) (19)	Up to March 2016	RCTs	6 Studies, 18–64 patients per study	T2DM	Chronic periodontitis	Laser therapy or antimicrobial photodynamic therapy after SRP	Clinical periodontal outcomes and glycemic outcomes	NA	Jadad	LT alone or aPDT showed significant improvement in the clinical periodontal parameters and glycemic levels in T2DM patients. Future RCTs are warranted to confirm these findings.
Abdul-jabbar, Vohra et al (2017) (20)	Up to October 2016	RCTs	4 Studies, 53–75 patients per study	DM	Chronic periodontitis	aPDT plus SRP/control SRP only	Clinical periodontal outcomes and glycemic outcomes	NA	Jadad	aPDT improved clinical periodontal and glycemic parameters in DM patients. When compared with SRP alone, none of the studies showed additional benefits of aPDT.
Al-Hamoudi (2017) (21)	Up to May 2017	RCTs	6 Studies in Brazil and Saudi Arabia. Number of participants, 20–30; 4 studies of patients with T2DM, 3 studies with cigarette smokers	T2DM	Chronic periodontitis	SRP plus aPDT, (control SRP only)	Clinical (PD reduction and CAL gain): microbiological (bacterial count) and immunological (cytokine profile) outcomes	Smoking	Modified Jadad quality scale for reporting randomized controlled trials	SRP plus aPDT improved clinical periodontal and immunological parameters in T2DM and cigarette smokers, no benefits of aPDT compared with SRP alone.
Azarpazhooh and Leake (2006) (22)	Up to July 2005	Case-control and cross-sectional for COPD	Periodontal disease and COPD: 2 cross-sectional studies and 2 case-control studies; 46 to 13,792 participants	COPD	Periodontal disease, tooth loss (dentulous and edentulous patients): dental plaque	Tooth brushing, decontamination/ rinsing	Risk of pneumonia/risk of COPD	NA	NA	Fair evidence of an association of pneumonia with oral health, poor evidence supporting a weak association (OR <2.0) between COPD and oral health, good evidence (I, grade A recommendation) that oropharyngeal decontamination with different antimicrobial interventions reduces the progression or occurrence of respiratory diseases.
Batista et al (2011) (23)	Up to May 2010	Longitudinal, cross-sectional, and case-control studies, measuring PD and	Longitudinal, cross-sectional, and case-control studies, measuring PD and athero-	Atherosclerosis	Periodontal disease: measures not standardized	NA	Intima-media thickness (atherosclerosis measure)	See Table 3 per study, no confounders assessed	NA	Although most studies reviewed found a positive association between PD and atherosclerosis, methodological limitations raise doubts on the validity. All included

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
		atherosclerosis clinically	sclerosis clinically					in all studies (mostly age and smoking)		studies found a significant association.
Botero et al (2016) (24)	1995 to July 2015	Systematic reviews, with or without meta-analysis	13 Systematic reviews, ranging from 2 studies with 143 participants to 35 studies with 2,565 participants (mostly included RCTs, some also non-RCTs)	DM type 1 and T2DM	Periodontitis	Nonsurgical periodontal treatment, with/ without antibiotics (2 studies, flap surgery)	Glycemic control: HbA1c or fasting glucose levels	NA	AMSTAR	Periodontal treatment could help improve glycemic control in patients with T2DM and periodontitis (10/12 systematic reviews with meta-analysis). Whether reduction in HbA1c values (0.23 to 1.03 percentage points) is significant for T2DM treatment and control is unclear. Impact of PT in patients with type 1 diabetes and adjunctive antimicrobials is inconclusive. Eight Reviews were of high quality, 5 moderate, 1 low. Three reviews had low risk of bias, 6 were unclear, and 5 high.
Dai et al (2015) (25)	Up to November 2013	Observational studies (clinical trials were excluded)	23 Observational studies: 6 tooth loss, 4 caries, 3 oral hygiene, 4 periodontal health, with 20–706 patients per study	Stroke	Tooth loss, periodontitis, caries experience	NA	Oral health outcomes and oral health–related behaviors	Oral health behaviors	MORE	Poorer oral health status among patients with a stroke diagnosis compared with healthy controls, greater tooth loss, higher dental caries experience, and poorer periodontal status.
D'Aiuto et al (2017) (26)	2005–2015	Systematic reviews/ meta-analyses	30 Systematic reviews: 5–78 studies included per review. Number of participants unclear. Various types of studies included in systematic reviews.	DM	Periodontal disease, tooth loss, caries	NA	Bidirectional relationship, oral health–diabetes	NA	AMSTAR	Strong evidence of T2DM being a risk factor for periodontal diseases, weak evidence in relation to type 1 diabetes. Weak evidence in relation to dental caries experience in children. Limited evidence of periodontitis being a risk factor for diabetes, but evidence of periodontal treatment leading to modest short-term improvement in glycemic control (not sustained beyond 3

Abbreviations: AMSTAR, Assessing the Methodological Quality of Systematic Reviews; aPDT, antimicrobial PhotoDynamic Therapy; BMI, body mass index; BMS, burning mouth syndrome; CAL, clinical attachment level (14); CAL, clinical attachment loss (29); CCT, controlled clinical trial; CHD, coronary heart disease; CI, confidence interval; c-IMT, carotid intima-media thickness; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; CsA, cyclosporin A; CVD, cardiovascular disease; DM, diabetes mellitus; FMD, flow-mediated dilation; GRADE Grading of Recommendations, Assessment, Development and Evaluations; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; HT, hypertension; ICD, International Classification of Diseases; IL, interleukin; LT, laser therapy; MA, meta-analysis; MI, myocardial infarction; MORE, Methodological Evaluation of Observational Research; NA, not applicable; NOS, Newcastle-Ottowa Scale; OCEBM, Centre for Evidence-Based Medicine, Oxford; OQAQ, Overview Quality Assessment Questionnaire; PD, probing depth; PPD, probing pocket depth; PT, periodontal therapy; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; OR, odds ratio; Ox-LDL, oxidized low-density lipoprotein; RCT, randomized controlled trial; SR, systematic review; SRP, scaling and root planing; T2DM, type 2 diabetes mellitus; TC, total cholesterol; TOAST, Trial of Org 10172 in Acute Stroke Treatment; WBC, white blood cell.

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
										months).
D'Aiuto et al (2013) (27)	Up to July 2012	RCT for meta-analysis	14 Studies: 32–160 participants per study	CVD	Periodontal disease	SRP or surgical treatment, tooth extraction, antibiotics	CVD risk factors	Biomarkers subject to methodological and environmental confounders	NA	Main consistent finding after periodontal therapy was a reduction of serum levels of CRP (stable measure of systemic inflammation) and an improvement of measures of endothelial function (which represents a surrogate marker of CVD).
Dietrich et al (2017) (28)	2005–2015	Systematic reviews and/ or meta-analyses	22 Systematic reviews. 3–89 studies per systematic review of various types. Number of participants not reported	CVD	Oral health: periodontitis, caries, tooth loss	Oral health promotion, periodontal treatment	NA	NA	AMSTAR and PRISMA	High quality evidence of association between CVD and oral health. Mainly association between chronic periodontitis and atherosclerotic heart disease and is independent of confounding factors. No causal relationship has been established. Firm association between oral health (periodontitis, caries and tooth loss) and atherosclerotic cardiovascular disease, that is, coronary heart disease, stroke, and peripheral vascular disease. Little or no evidence to support any links between oral health and other forms of cardiovascular disease that are non-atherosclerotic such as HT, arrhythmias, and heart failure. Periodontal therapy is associated with reductions in surrogate markers of atherosclerotic CVD.
Faggion et al (2016) (29)	Up to March 2015	Systematic reviews with meta-analysis	11 Meta-analyses, original studies based on 12–514 patients	DM type 1 and T2DM	Periodontal disease	Periodontal treatment	HbA1c levels	NA	AMSTAR and OQAQ	SRs showing an average decrease of 0.46% (median, 0.40%) of HbA1c levels. These values, nevertheless, are not significant when meta-analyses of longer follow-ups (up to 6 mos) are evaluated. Furthermore, most primary studies in-

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Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
										cluded in those SRs had several methodological limitations.
Hasuike et al (2017) (30)	Up to July 2015	Systematic reviews with meta-analysis	9 Studies, 60–1,135 participants	DM type 1 and T2DM	Periodontal disease	Periodontal treatment with or without adjunctive use of local drug delivery and systemic antibiotics.	Changes in HbA1c	NA	AMSTAR	Significant effect of periodontal treatment on improvement of HbA1c levels in diabetes patients, although effect size is extremely small. In addition to this small effect size, the supporting evidence cannot be regarded as high quality.
Kelly et al (2013) (31)	Up to May 2012	Systematic reviews	13 Systematic reviews, 9 with meta-analyses. Not reported how many studies were included in each systematic review	Chronic heart disease	Periodontal disease	NA	Quality appraisal	NA	AMSTAR and Glenny et al (51)	Apart from analyzing the methodological and structural quality of the selected systematic reviews and meta-analyses, we did not attempt to perform any outcome analyses. There was substantial heterogeneity in the types of articles included in the 13 reviews, with varying study designs including cohort, cross-sectional, case-control, and RCTs.
Kothari et al (2017) (32)	Through January 2016	Observational studies, case-control studies, and 1 mixed-methods study	27 Studies; no information on number of participants per study	Acquired brain injury, including cerebrovascular diseases	Tooth loss, periodontal status, caries	Professional oral health care or oral hygiene instruction (in some studies)	NA	NA	NA	Currently low level of interest in topic. All included studies reported poor oral health in patients with brain injury. Studies also showed significant improvements in oral health if appropriate measures were implemented at rehabilitation settings. Stroke patients seemed to present with higher incidence of missing teeth and tooth mobility.
Lafon et al (2014) (33)	Up to April 2012	Cohort studies	9 Studies: 5 in North America, started during 1970–1980. Participants ranged from	Stroke	Periodontal disease	NA	Periodontitis and tooth loss	NA	Evaluation grid	Results suggested a link between stroke and periodontal diseases. The association was significant for periodontitis and tooth loss. The risk of ischemic or hemor-

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/Confounders	Quality Assessment Tool Used	Conclusions
			1,137–51,529. Length of follow-up from 12–57 years							rhagic stroke was higher in people with periodontitis (estimated adjusted risk, 1.63 [1.25–2.00]). Tooth loss was also a significant risk factor for stroke (estimated adjusted risk, 1.39 [1.13–1.65]). In this review, gingivitis did not significantly influence the occurrence of stroke.
Lam et al (2011) (34)	NA	3 RCTs, 3 pre–post interventions, 1 split-mouth, 1 quasi-experimental	8 Studies, ranging from 6–303 patients	CVD	Oral health: periodontal health	Oral health instruction, extractions, periodontal treatment	Periodontal health and changes in systemic blood marker levels	NA	NA	Periodontal interventions were found to be capable of modifying numerous surrogate markers of cardiovascular outcomes including CRP, Ox-LDL, WBC, fibrinogen, IL-6, and endothelial dysfunction. It must be accepted, however, that neither a cause-and-effect relationship, nor the exact mechanism whereby periodontal disease may affect cardiovascular disease risk has been established. Whether the reduction of systemic inflammatory markers can truly decrease the risk of secondary cardiovascular events remains to be shown by studies of longer duration. Interventions aimed at improving periodontal parameters such as plaque and gingival bleeding were successful in patients with HT, CHD, and previous heart transplantation. Periodontal interventions were less successful at effecting changes in CsA-induced gingival overgrowth in heart transplantation patients. None of the effective articles included assessments on the effect of oral promotion interventions on oral microflora.

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Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
Leira et al (2017) (35)	Up to March 2015	3 cohort (retrospective and prospective), 5 case-control studies	8 Studies, 95–9,962 patients. Europe, North America, and Asia. Data collected between 1968 and 2012	Ischemic stroke (assessed as acute ischemic lesion on brain imaging and/ or neurological deficit, TOAST and ICD)	Periodontitis (assessed with CAL, PPD, and radiographic bone loss)	NA	Risk of ischemic stroke	Most commonly adjusted vascular risk factors were: age, sex, DM, HT, smoking status, hypercholesterolemia, and BMI	GRADE	Suggested a positive association between ischemic stroke and prevalence of periodontitis. The risk of cerebral ischemia was higher in subjects with periodontitis (RR, 2.88 [95% CI, 1.53–5.41]).
Leng et al (2015) (36)	Up to May 2015	Prospective cohort studies	15 Studies enrolling 230–406 participants	Coronary heart disease	Periodontal disease	NA	CHD-related morbidity (fatal and nonfatal) or mortality, evaluated using relative risk or hazard ratio	Sex, BMI, smoking, age, family history of heart disease, education, blood pressure (most common confounders)	NA	Patients with periodontal disease were at a significantly increased risk of developing CHD (RR, 1.19; 95% CI, 1.13–1.26; *P* < .001). Subgroup analyses according to the effect measure, adjustment for confounding factors, median follow-up time, country of study origin, assessment method of periodontal disease, and sex all indicated significant associations between periodontal disease and CHD.
Li et al (2014) (37)	Up to April 2014	RCT and quasi-RCT	1 RCT, 303 participants	CVD	Chronic periodontitis	SRP and community care	Cardiovascular events	NA	Cochrane's RoB assessment tool, GRADE	The study recorded 12 cardiovascular events, but results were not significant. Also, serum high sensitivity CRP: who had high CRP, and adverse events all reported nonsignificant results. Because only 1 was study eligible for inclusion, which was also judged to be at high risk of bias, the results should be interpreted with caution.
Lira et al (2017) (38)	Up to September 2016	Clinical trials	12 Studies qualitative analysis; 8 meta-analyses, 30–70 pa-	DM	Periodontal disease	Adjunctive use of systemic antibiotics in nonsurgic-	Changes in HbA1c	NA	Cochrane's RoB assessment tool	Shows no additional benefit of associating systemic antibiotics to nonsurgical periodontal treatment versus SRP alone in improving

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
			tients per study			al periodontal treatment, compared with nonsurgical periodontal treatment alone.				HbA1c levels 3–4 months after treatment.
Martin-Cabezas et al (2016) (39)	2000 to June 2016	Longitudinal studies or case-control studies and cross-sectional studies	25 Studies in review; 18 in meta-analysis: 20 cross-sectional, 3 case-control, and 2 longitudinal studies, across Asia, Europe, United States, and Africa. Ranging from 8,124–1,025, 340 participants.	HT	Periodontal disease	NA	HT	Age, sex, smoking, BMI, binge drinking	NOS	Results from the present meta-analysis support the association between HT and periodontal diseases with a range of ORs from 1.15 to 1.67. Highest OR was calculated when severe form of periodontitis with secure diagnosis criteria was considered (OR, 1.64).
Mauri-Obradors et al (2017) (40)	1998 to January 2016	Primary studies	19 Studies: 4× longitudinal studies; 15× cross-sectional studies. A total of 3,712 patients, of whom 2,084 had diabetes.	DM type 1 and T2DM	Caries, periodontal disease, BMS, oral mucosa alterations	NA	Oral manifestations	NA	Recommendations made by OCEBM	DM leads to multiple complications, which increase when glycemic control of the patient is inadequate. The main oral complication attributed to diabetes is periodontal disease: considered the sixth complication of DM. Higher prevalence of periapical lesions in patients with poorly controlled diabetes. Information presented in the literature about the relationship between the DM and tooth decay is inconsistent.
Orlandi et al (2014) (41)	Through January 2014	Cross-sectional studies, case-control studies, population	35 Studies for systematic review, 22 studies for meta-analysis; 2,021	c-IMT; FMD	Periodontitis	Periodontal intervention	Increase in c-IMT. Effects of periodontal treatment on FMD.	CVD (age, sex, systolic blood pressure, HDL-C,	Newcastle-Ottawa Quality Assessment Scale	Diagnosis of PD was associated with a mean increase in c-IMT of 0.08 mm (95% CI, 0.07–0.09 mm) and a mean difference in FMD of

Abbreviations: AMSTAR, Assessing the Methodological Quality of Systematic Reviews; aPDT, antimicrobial PhotoDynamic Therapy; BMI, body mass index; BMS, burning mouth syndrome; CAL, clinical attachment level (14); CAL, clinical attachment loss (29); CCT, controlled clinical trial; CHD, coronary heart disease; CI, confidence interval; c-IMT, carotid intima-media thickness; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; CsA, cyclosporin A; CVD, cardiovascular disease; DM, diabetes mellitus; FMD, flow-mediated dilation; GRADE Grading of Recommendations, Assessment, Development and Evaluations; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; HT, hypertension; ICD, International Classification of Diseases; IL, interleukin; LT, laser therapy; MA, meta-analysis; MI, myocardial infarction; MORE, Methodological Evaluation of Observational Research; NA, not applicable; NOS, Newcastle-Ottowa Scale; OCEBM, Centre for Evidence-Based Medicine, Oxford; OQAQ, Overview Quality Assessment Questionnaire; PD, probing depth; PPD, probing pocket depth; PT, periodontal therapy; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; OR, odds ratio; Ox-LDL, oxidized low-density lipoprotein; RCT, randomized controlled trial; SR, systematic review; SRP, scaling and root planing; T2DM, type 2 diabetes mellitus; TC, total cholesterol; TOAST, Trial of Org 10172 in Acute Stroke Treatment; WBC, white blood cell.

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
		surveys, cohort studies, pilot studies, controlled trials, RCTs	cases, 3,431 control					smoking, diabetes, HT treatment, and total cholesterol). Atherosclerosis		5.1% compared with controls (95% CI, 2.08%–8.11%). A meta-analysis of the effects of periodontal treatment on FMD showed a mean improvement of 6.64% between test and control (95% CI, 2.83%–10.44%). Periodontal disease is associated with greater subclinical atherosclerosis as assessed by increased c-IMT and an independent predictor of cardiovascular events in high-risk populations. There is evidence of an impaired FMD, which is restored by periodontal treatment in individuals having periodontal disease.
Sanchez et al (2017) (42)	NA	3 MA/SR of RCT, 1 MA/SR of RCT and single cohort studies, 1 SR of oral health promotion interventions, 1x SR of RCT/quasi-RCT, 1 MA/SR, 1 MA/SR of intervention trials, 1 MA of pilot trials, 1 MA/SR of intervention and nonintervention trials, SR of intervention trials; 2 SR, 1 LR, 1x pre–post mixed design, 1 pilot of an	34 Studies included from Australia, Europe, United States, France, Italy, United Kingdom, Turkey, Sweden, England	CVD	Periodontal disease	Periodontal treatment	CVD	NA	AMSTAR	Strong association between periodontal disease and CVD. Although a causal link has not been confirmed between periodontal disease and CVD, the general consensus is that cardiovascular patients need to be made aware of this association and its potential implications.

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Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
		oral health program, 1 oral health guidelines for prenatal care, 1x best practice recommendations; 1 RCT, 1 pre–post test design, 1 pilot of an education program, 1 pre–post mixed design, 1 pilot of an oral health education model, 2 cross-sectional studies, 3 pilots of a screening tool, 1 best practice recommendations								
Schmitt et al (2015) (43)	Up to September 2014	RCTs: case-control studies, cross-sectional studies, prospective cohort pilot study	Studies included in qualitative synthesis = 10; studies included in quantitative synthesis =7; sample size in total 2,257 (range, 26–814)	Arterial stiffness	Periodontitis	Periodontal treatment	Primary outcome had to be the measure of arterial stiffness by means of pulse wave velocity assessment.	Age, sex, smoking, or diabetes	GRADE system	The present systematic review and meta-analysis support an association between severe periodontitis and increased pulse wave velocity. The measurement of arterial stiffness provides a cardiovascular marker of the cumulative impact of both known and unknown risk factors, which may include periodontitis.
Teeuw et al (2014) (44)	Up to June 2013	RCTs, CCTs	Studies included n = 20; cases in total n = 865 (11–212 patients per study)/control	Atherosclerosis	Periodontitis	Treatment of periodontitis	Clinical CVD parameters (ie, clinical event, such as angina pectoris, MI, stroke, death) and/or mark-	Overweight and smoking	GRADE	PT reduces the risk for CVD by improving plasma levels of inflammatory (CRP, IL-6, TNF-a), thrombotic (fibrinogen), and metabolic (triglycerides, TC, HDL-C, HbA1c) markers and endothelial

Abbreviations: AMSTAR, Assessing the Methodological Quality of Systematic Reviews; aPDT, antimicrobial PhotoDynamic Therapy; BMI, body mass index; BMS, burning mouth syndrome; CAL, clinical attachment level (14); CAL, clinical attachment loss (29); CCT, controlled clinical trial; CHD, coronary heart disease; CI, confidence interval; c-IMT, carotid intima-media thickness; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; CsA, cyclosporin A; CVD, cardiovascular disease; DM, diabetes mellitus; FMD, flow-mediated dilation; GRADE Grading of Recommendations, Assessment, Development and Evaluations; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; HT, hypertension; ICD, International Classification of Diseases; IL, interleukin; LT, laser therapy; MA, meta-analysis; MI, myocardial infarction; MORE, Methodological Evaluation of Observational Research; NA, not applicable; NOS, Newcastle-Ottowa Scale; OCEBM, Centre for Evidence-Based Medicine, Oxford; OQAQ, Overview Quality Assessment Questionnaire; PD, probing depth; PPD, probing pocket depth; PT, periodontal therapy; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; OR, odds ratio; Ox-LDL, oxidized low-density lipoprotein; RCT, randomized controlled trial; SR, systematic review; SRP, scaling and root planing; T2DM, type 2 diabetes mellitus; TC, total cholesterol; TOAST, Trial of Org 10172 in Acute Stroke Treatment; WBC, white blood cell.

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Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
			in total n = 657 (11–105 patients per study). Cases and control in total n = 1522.				ers related to atherosclerosis and CVD risk, including markers of systemic inflammation and thrombosis, lipid and glucose metabolism, and vascular function.			function. This improvement is sustained well more than 6 months after therapy, and it is greater in those individuals having both periodontitis and co-morbidities like CVD and/or DM. Our findings emphasize the effectiveness and need for periodontal diagnosis and periodontal therapy in atherosclerotic and diabetic individuals to improve their systemic health.
Tonsekar et al (2017) (45)	Up to April 2016	4x retrospective cohort, 3x prospective cohort, 1x case-control study nested in a longitudinal study	Studies included n = 8; 4,075 participants; number of participants 144 to 911; countries: United States, South Korea, France, Sweden.	Dementia	Periodontal disease, tooth loss	NA	Outcome measured was assessed by verified cognitive tests such as Mini-Mental State Examination: Delayed Word Recall and Digit Symbol Substitution Test.	Apolipoprotein E (ApoE) allele, considered a major genetic risk factor for Alzheimer disease and a possible confounding factor in the association between periodontitis and dementia.	Newcastle-Ottawa Scale	Association between subsequent dementia, periodontal disease and tooth loss was inconclusive.
Ungprasert et al (2017) (46)	Up to July 2016	Case-control or cohort study	Studies included n = 5; number of subjects (cases/ comparators) 1) 115,365/ 115,365; 2) 1,358/70,020; 3) 100/100; 4) 50/121; 5) 60/45. The 5 studies included	Psoriasis	Periodontitis	NA	Periodontitis and risk of psoriasis	Confounders: smoking, obesity, and DM	Newcastle–Ottawa quality assessment scale	Patients with periodontitis have a significantly increased risk of psoriasis.

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
			312,584 subjects. Countries: Taiwan, United States, Greece, Norway, Italy.							
Xu et al (2017) (47)	Up to July 2016	6x cross-sectional, 12x case control, 4x cohort studies	Studies included n = 22; 129,630 participants; countries: United States, Sweden, Japan, India, Spain, Iran, China, Germany, Greece.	MI	Periodontal disease	NA	Periodontal disease (including pocket probing depth, attachment loss, bleeding on probing, plaque index, gingival index, X-ray, and microbiological results) and the risk of myocardial infarction	Risk factors including age, smoking, and diabetes are common in both PD and MI	Newcastle-Ottawa Scale	Significant association between periodontal disease and MI. Subgroup analyses also confirmed the elevated risk for MI in periodontal disease subjects.
Zeng, Leng et al (2016) (48)	Up to February 20, 2015	10x cross-sectional, 5x case control	Studies included n = 15; 17,330 participants; countries: United States, Sweden, Germany, Austria, Italy, Spain, Japan, Portugal, Poland, South Korea, China.	Carotid atherosclerosis	Periodontal disease	NA	Risk of carotid atherosclerosis as diagnosed by c-IMT (by ultrasound) or carotid plaque thickness (by panoramic radiographs)	Common risk factor: smoking; confounder: DM	NA	Periodontal disease was associated with carotid atherosclerosis, although available evidence is insufficient to confirm the causal relationship of periodontal disease and carotid atherosclerosis.
Zeng et al (2012) (49)	Up to January 10, 2012	Observational studies (cross-sectional, case-control, or cohort design)	Studies included n = 14; subjects (case/control): between 28/30 and 810/12,982. Countries: United States, Poland, Norway, Iran, China, India.	COPD	Periodontal disease	NA	Relationship between PD and COPD	NA	NA	Periodontal disease significantly increases the risk of COPD, with the increase being likely independent of conventional COPD risk factors. Dental plaque that contains bacteria may be responsible for COPD, therefore, good attention to teeth brushing and general oral hygiene care may reduce the risk of COPD.
Zeng, Xia	Up to June	Cohort and	Studies in-	Lung Can-	Periodontal disease	NA	Risk of lung	Smoking	NA	Periodontal disease is asso-

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Table 2. Characteristics of Included Systematic Reviews, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017

Study	Years Searched	Study Type(s)	Population	Chronic Systemic Disease	Dental Disease	Interventions	Outcome	Common Risk Factors/ Confounders	Quality Assessment Tool Used	Conclusions
et al (2016) (50)	10, 2015	nested case-control studies	cluded n = 5; subjects: (lung cancer/ sample): 1)191/ 11,328; 2)236/ 48,375; 3) 225/30,666; 4) 243/ 153,566; 5) 754/77,485. Countries: United States, Sweden, China.	cer	al disease		cancer in patients with periodontal disease			ciated with a significant and increased risk of lung cancer.

Abbreviations: AMSTAR, Assessing the Methodological Quality of Systematic Reviews; aPDT, antimicrobial PhotoDynamic Therapy; BMI, body mass index; BMS, burning mouth syndrome; CAL, clinical attachment level (14); CAL, clinical attachment loss (29); CCT, controlled clinical trial; CHD, coronary heart disease; CI, confidence interval; c-IMT, carotid intima-media thickness; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; CsA, cyclosporin A; CVD, cardiovascular disease; DM, diabetes mellitus; FMD, flow-mediated dilation; GRADE Grading of Recommendations, Assessment, Development and Evaluations; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; HT, hypertension; ICD, International Classification of Diseases; IL, interleukin; LT, laser therapy; MA, meta-analysis; MI, myocardial infarction; MORE, Methodological Evaluation of Observational Research; NA, not applicable; NOS, Newcastle-Ottowa Scale; OCEBM, Centre for Evidence-Based Medicine, Oxford; OQAQ, Overview Quality Assessment Questionnaire; PD, probing depth; PPD, probing pocket depth; PT, periodontal therapy; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; OR, odds ratio; Ox-LDL, oxidized low-density lipoprotein; RCT, randomized controlled trial; SR, systematic review; SRP, scaling and root planing; T2DM, type 2 diabetes mellitus; TC, total cholesterol; TOAST, Trial of Org 10172 in Acute Stroke Treatment; WBC, white blood cell.

Table 3. Number of Systematic Reviews Observing Disease Correlations, Systematic Umbrella Review of Correlation Between Prevalent Dental Conditions and Chronic Diseases, 1995–2017[a]

Dental or Chronic Disease	Periodontitis	Tooth Loss	Dental Caries	
Diabetes mellitus	46 (41/5)	1 (1/0)	4 (1/3)	51
Cardiovascular disease	33 (22/11)	6 (6/0)	2 (1/1)	41
Cerebrovascular disease	4 (0/4)	2 (0/2)	2 (0/2)	8
Chronic obstructive pulmonary disease	2 (0/2)	1 (0/1)	—	3
Dementia	1 (0/1)	1 (0/1)	—	2
Psoriasis	1 (0/1)	—	—	1
Lung cancer	1 (0/1)	—	—	1
Total	**88**	**11**	**8**	**107**

Abbreviation: — , not applicable.
[a] The first number in the parentheses indicates the number of systematic reviews included in the umbrella review; the second number indicates the number of reviews that were individually included in the systematic reviews.

PREVENTING CHRONIC DISEASE
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GIS SNAPSHOTS

Visualizing County-Level Data to Target Dental Safety-Net Programs for Children

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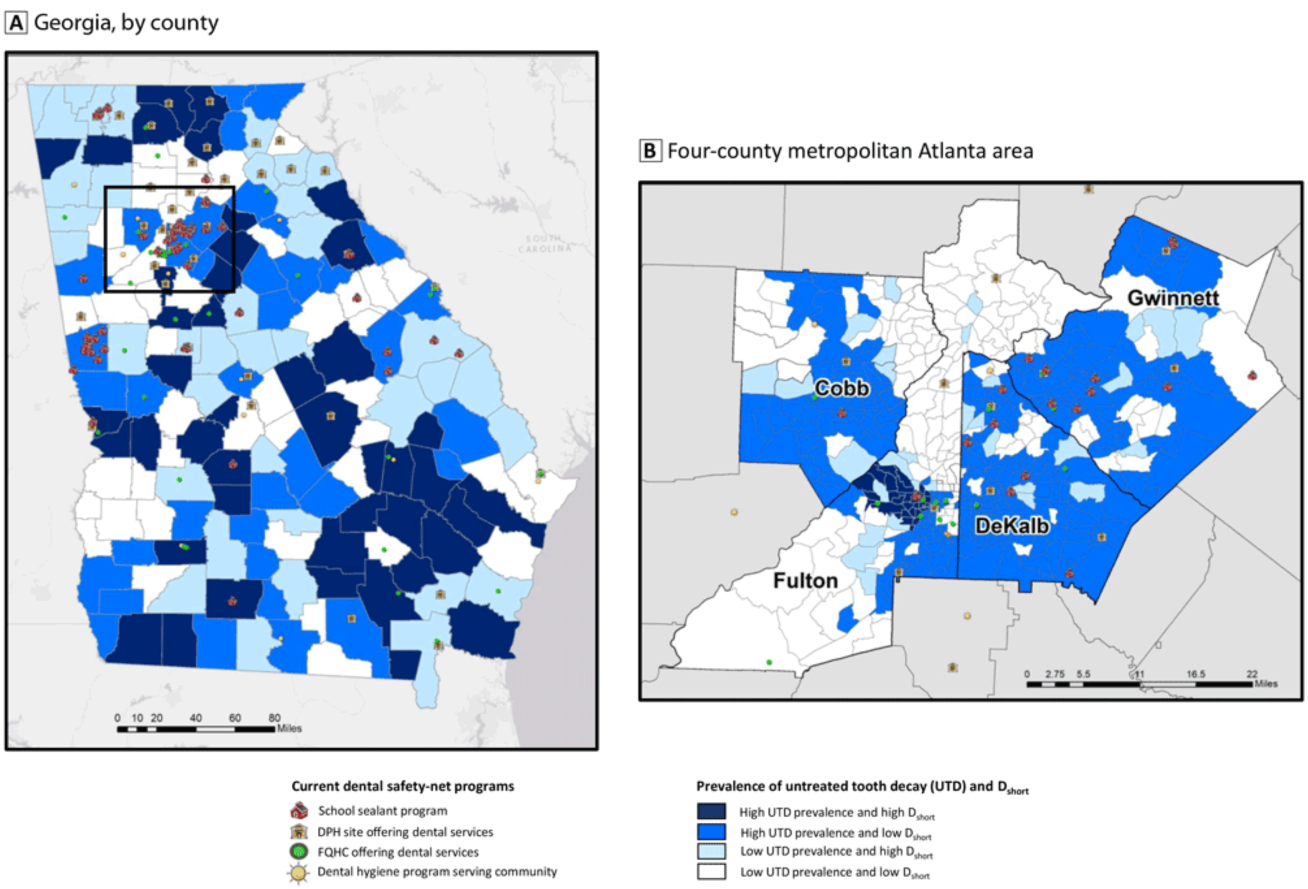

Current dental safety-net programs and areas of need for children aged 6 to 9 years. A, In Georgia, by county. Inset indicates the metropolitan Atlanta area. B, Metropolitan Atlanta area, by census tract. Maps were created by a data visualization tool that can be used to evaluate allocation of dental safety-net programs across the state and to inform decision makers on future resource needs and allocation. D_{short} represents the severity of a dental workforce shortage and is quantified as the number of full-time equivalent dental practitioners required to make the area a nonshortage area. Data sources: Lin et al (7), Health Resources and Services Administration (8), Georgia Department of Public Health (DPH) Oral Health Program (9), Georgia Primary Care Association (10), and Georgia Oral Health Coalition (11). Abbreviations: D_{short}, shortage of dental practitioners; FQHC, federally qualified health center; UTD, untreated tooth decay.

Background

More than 19% of third-graders in Georgia had untreated dental caries (tooth decay) in 2016–2017 (1). The national average among children of similar age (6–9 y) was 15.5% in 2013–2016 (2). Untreated tooth decay can cause pain and infection and impair eating, speaking, and learning. Among children it can lead to missed school days and lower academic performance (3). The most recent US data indicated that 34 million school hours were missed in 2007 as a result of acute unplanned dental care needs (4).

Dental sealants (5), topical fluoride (6), and restorative care are effective in preventing tooth decay. Most caries-prevention programs are implemented at the local level. The prevalence of untreated tooth decay, however, varies by geographic area — ranging from 8.2% to 32% among third-graders across 29 states during 2013–2016 (1). By county, modeled estimates among children aged 6 to 9 years nationwide ranged from 4.9% to 65.2% (7). Thus, having local data on the risk of untreated tooth decay and dental workforce capacity is critical to effectively target dental safety-net programs for children at highest risk of untreated tooth decay.

We developed a data visualization tool that maps county-level need for caries prevention and treatment programs and the distribution of dental safety-net programs in Georgia. This tool can be used by public health decision makers to 1) assess how well dental safety-net programs are currently allocated and 2) plan and target future programs.

Data and Methods

We estimated the need for dental safety-net programs for each of the 159 Georgia counties and for each census tract in the 4 metropolitan Atlanta counties: Cobb (120 census tracts), DeKalb (143 census tracts), Fulton (202 census tracts), and Gwinnett (113 census tracts). Level of need was based on the estimated prevalence of untreated tooth decay and the severity of a dental workforce shortage (D_{short}). We obtained data on the prevalence of untreated tooth decay from a study that estimated this information for children aged 6 to 9 years (7). That study generated county and census-tract estimates based on a multilevel regression and poststratification method applied to data on caries and sociodemographic characteristics from the National Health and Nutrition Examination Survey 2005–2010 linked with various area-level data at census tract, county, and state levels (7). We defined counties with an estimated prevalence of untreated tooth decay at or above the state's median (20.1%) as having a high prevalence of untreated tooth decay (range, 20.1%–49.5%) and counties with a prevalence below the median as having a low prevalence of untreated tooth decay (range, 8.5%–19.9%).

We used data from the Health Resources and Services Administration (HRSA) (8) on the shortage of dental practitioners in each Georgia county designated as a geographic or population-based Dental Health Professional Shortage Area (DHPSA). For these counties, HRSA provides estimates of the number of full-time equivalent dental practitioners required to make the county a nonshortage area. We used the term "D_{short}" to indicate levels of dental shortages; the higher the D_{short} values, the greater the shortage. Non-DHPSA counties are not assigned a value by HRSA, so we assigned a value of 0 to these counties. We used D_{short} instead of DHPSA designation as an indicator of workforce capacity because DHPSA designation was less specific — more than three-quarters of Georgia counties were DHPSAs. We designated counties and metropolitan Atlanta census tracts with values at or above the state's median (1.34) as high D_{short} areas (range, 1.34–29.43) and census tracts below the median (range, 0–1.31) as low D_{short} areas.

We assigned counties to 1 of 4 categories: 1) low prevalence of untreated tooth decay and low D_{short}, 2) low prevalence of untreated tooth decay and high D_{short}, 3) high prevalence of untreated tooth decay and low D_{short}, and 4) high prevalence of untreated tooth decay and high D_{short}. We designated counties in category 4 as having the greatest need for dental safety-net programs and counties in category 1 as having the least need. We designated counties in category 3 as having a greater need for dental safety-net programs than those in category 2 because of their higher prevalence of untreated tooth decay.

We then overlaid information on current Georgia dental safety-net programs onto county need for such programs. Dental safety-net programs included 1) state-sponsored school sealant programs, 2) county-funded public health departments offering dental services, 3) federally qualified health centers offering dental services, and 4) dental hygiene programs providing community dental services. We obtained information on school sealant programs from the Georgia Department of Public Health Oral Health Program (9), information on federally qualified health centers from the Georgia Primary Care Association (10), and information on public health department dental sites and dental hygiene programs from the Georgia Oral Health Coalition (11). We generated maps by using ArcGIS version 10.5 and ArcGIS online (Esri).

Highlights

Our visualization indicated good allocation of scarce dental public health resources. Of the 131 dental safety-net programs, 88 (67.2%) were in high-need counties, which is twice the number in low-need counties (43 or 32.8%). Many high-need counties, however, did not have dental safety-net programs. Among the 80 high-need counties, 52 had no programs (29 in category 4; 23 in category 3). In high-need areas, programs were more common in the metropolitan Atlanta area than in the rest of the state. This information is important for planning purposes, although the state may not be able to immediately address the problem of dental shortages in nonmetropolitan counties because of resource constraints and the higher cost (eg, longer driving time to transport dental professionals and portable sealant equipment) of serving areas farther away from the State Oral Health Program, which is based in Atlanta.

The maps also illustrate the importance of a granular visualization in areas with diverse populations, such as metropolitan areas. If only county levels are used, small pockets of need may be missed, as in Fulton County. Visualization at the census-tract level in Fulton County provides a better assessment of need and targeting.

Action

Our mapping technique provides decision makers in Georgia with a visual tool for assessing how well current dental safety-net programs are allocated across the state and identify gaps in resource allocation where needs could be addressed in future program planning. The data used to generate these maps are publicly available for states nationwide and thus, these maps could be replicated throughout the United States.

Acknowledgments

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PREVENTING CHRONIC DISEASE

PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY

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GIS SNAPSHOTS

Visualizing Potential Effects of Dentist Retirements on Accessibility to Dental Care Among Children in Alabama, 2019

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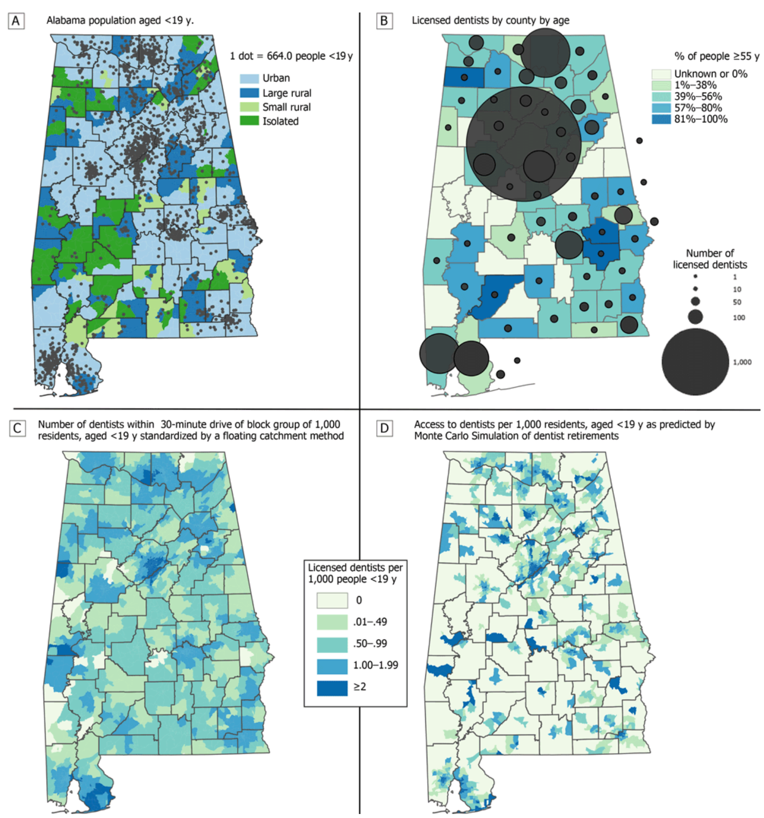

Four maps show the distribution of population and dentists in Alabama. Map A shows the distribution of the population aged 20 or younger; Map B, the distribution of licensed dentists by age across counties (counties with fewer than 3 dentists are not included); Map C, the number of dentists within a 30-minute drive of a block group of 1,000 residents aged 20 or younger, standardized by a floating catchment method; and Map D, shows access to dentists per 1,000 residents aged 20 or younger, as predicted by a Monte Carlo simulation of dentist retirements. Maps B and C include dentists' data at the latitude and longitude point-level. Sources: 2018 American Community Survey 5-Year Estimates (8), Alabama Board of Dental Examiners (9), Rural Health Research Center (13), ESRI StreetMap Premium ArcGIS Pro version 2.5.0 (Esri), Python version 3.4 (Jupyter Project), and NAD 1983 HARN StatePlane Alabama West FIPS 0102 (Esri).

Background

Regular dental visits can prevent dental problems (1,2). Under half of the US population aged 44 or younger is estimated to have untreated dental caries (3), and regular dental care during childhood can benefit oral health outcomes as an adult (2). Despite this evidence, access to dental care in the United States remains a challenge, especially among economically or socially marginalized groups (4). In 2018, only 230,490 of 736,103 (31.3%) beneficiaries under age 21 enrolled in Alabama's Medicaid program used dental services (5). A crucial, but often overlooked barrier to dental accessibility in the United States is the aging of the dental workforce. In 2016, an estimated 40% of US dentists were aged 55 or older compared with 27% in 2001 (6). Data suggest that more than half of Alabama dentists are aged 50 or older (7), which indicates that a large number are expected to retire in the near future, which could result in a shortage of dentists.

The objective of our analysis was 2-fold. First, we aimed to highlight access to dentists among Alabamians aged 20 or younger in the context of evaluating a dental network adequacy policy that promotes access to dental care for all people aged 20 or younger, living 30 minutes or less of driving time from a licensed dentist. We then used national dentist retirement rates to describe the implications of such retirements on access to dental care.

Data and methods

Our study focuses on dental accessibility among young Alabama residents (<21 y) where each block group (n = 3,437) population count of young residents, as recorded in American Community Survey 5-year estimates of the 2018 US Census (8), was represented as the geometric center of its respective block group. We define accessibility as geospatial proximity to a state-licensed dentist in relation to a person's home residence. The Alabama Board of Dental Examiners (9) provided 2020 data that was deidentified and geocoded at latitude and longitude point-levels. Statistics from the American Dental Association's Health Policy Institute (7) were used to estimate the likelihood of a dentist retiring in the upcoming year, based on the age provided in the dental provider data (10).

We used a 30-trial Monte Carlo simulation to simulate the effects of dentist retirements on access to dental care for residents aged 20 or younger. Similar to previous analyses (11), a 2-step floating catchment area method was employed to estimate accessibility to dentists in Alabama, and we used Monte Carlo methods to simulate future accessibility. We generated retirement scenarios that allowed us to assess the potential effect of dentist retirements on accessibility on the basis of the ages of currently practicing dentists and published retirement rates (10). Full systematic details on how this analysis was conducted with statistical formulas and Python code can be found at https://bit.ly/githubAccessBama.

Average differences and variances in accessibility estimates were observed in a simulation of dentist retirements to better understand differences in geospatial accessibility after accounting for the retirements. Comparisons of physical access to dental care by rurality augmented the retirement scenario. Rurality was operationalized by using the 2019 rural–urban commuting area codes from the Rural Health Research Center's 4-level categorization (Rural Health Research Center). Automobile travel times were generated by using ESRI Streetmap Premium 2019 (Esri). All analyses were generated with ArcGIS Pro 2.5.0 (Esri) and Python 3.4 (Jupyter Project) by using multiple libraries. We used the Kruskal–Wallis test to examine differences in accessibility scores by rurality. Although findings presented in this article reflect modeling assumptions (eg, applying a drive-time catchment threshold of 30 minutes) used by the American Dental Association in an earlier study (11), interactive maps with the ability to manipulate various assumptions are available on a Tableau Software public dashboard (Supplemental file at https://public.tableau.com/shared/23ZDYJ77R).

Highlights

The percentage of dentists who were likely to retire within the calendar year was 2.5% for those aged 34 or younger; 2.3%, 35 to 44; 4.0%, 45 to 54; 15.9%, 55 to 64; 40.9%, 65 to 74; 61.4%, 75 to 84; and 80.6%, 85 or older. On the basis of map analyses describing accessibility, we came to 3 conclusions. First, young people's access to dentists appeared to be higher in Alabama urban areas than in rural areas ($P < .001$) (Table). The average accessibility score of an urban census block was about 1.28 dentists per 1,000 young people compared with about 0.85 dentists per 1,000 youths in rural areas. Second, considering our simulation of dentist retirements, rural regions on average would be more affected by retirements than urban regions. Third, although the retirement of aging dentists appeared, potentially, to affect various areas of Alabama, the southwest corner of the state appeared to be the most vulnerable.

Observation of the Tableau software public dashboard suggested that modifying the travel time threshold to operationalize access had a greater effect on young people in urban areas than young people in the rural southwestern and lower-central regions of Alabama. The high density of dentists working in urban regions most likely accounts for this difference. Although we focused on the outflow of dentists, some studies suggest that dental school graduates are more likely to seek employment in urban areas than in rural areas (12), which suggests that our results would be more pronounced if we included inflow estimation rates. Our maps and the online Tableau Software dashboard provide evidence that the potential retirement of aging dentists jeopardizes dental care access for young people in Alabama, especially those in rural areas. Stakeholders including the US Public Health Service (USPHS), the Alabama Medicaid Agency, and the Alabama Department of Public Health can utilize these preliminary findings to develop strategies for targeted investigations on possible clinical effects of this phenomenon. USPHS often provides incentives, such as scholarships and student loan forgiveness for enrolled clinicians willing to practice in underserved areas. The Alabama Medicaid Agency provides a significant amount of dental care to young people in Alabama, particularly those in rural areas where a large portion of citizens are enrolled in Medicaid.

Actions

Our study has limitations. First, only license information for dentists in Alabama were used in analyses. Young people in counties that border the neighboring states might choose to use the service of a dentist not licensed in Alabama. Our analyses, therefore, may have edge effect biases. Another limitation is that we focus on dentists retiring (outflow) and do not consider new dentists joining the workforce (inflow). We do this to provide a worst-case estimation of future dental care accessibility; however, future studies may also incorporate the inflow of dentists. Nonetheless, strengths in our analyses balance its limitations.

Our study is one of the few analyses in Alabama to assess the relationship between dentist age and access to dental care. To our knowledge, this is the first study to visualize the effect of dentist retirements on dental care accessibility, which has the potential to serve as a preliminary step in a planning management strategy for the allocation of dentists in areas of need. Institutions outside of Alabama can use our methods to estimate accessibility in their regions to examine the effects of key policy decisions before implementation.

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Table

Table. Potential Effects of Dentist Retirements on Children in Alabama: Descriptives and Accessibility Scores[b,c,d] by Rural Status[a]

Population	Urban	Large Rural	Small Rural	Isolated	Statewide
<20 y, n (%)	1,022,520 (78.5)	201,338 (15.5)	25,895 (2.0)	52,413 (4.0)	1,302,166 (100.0)
Block groups, n (%)	2,571 (74.8)	583 (17.0)	91 (2.6)	191 (5.6)	3,436 (100.0)
Percentile ranked baseline accessibility scores, providers per 1,000 population aged <18 y					
10th	0.46	0.44	0.32	0.25	0.43
25th	0.84	0.64	0.46	0.56	0.72
Median	1.28	0.80	0.64	0.77	1.12
75th	1.70	0.97	0.88	0.92	1.54
90th	2.24	1.42	1.09	1.32	2.11
Percentile ranked retirement simulated accessibility scores, providers per 1,000 population aged <18 y					
10th	0	0	0	0	0
25th	0.18	0	0	0	0.05
Median	0.71	0.70	0	0	0.66
75th	1.61	1.14	0.72	0.87	1.46
90th	2.58	1.90	1.26	1.79	2.41

[a] Rurality based on the Rural Health Research Center’s 4-Level Categorization at https://depts.washington.edu/uwruca/ruca-maps.php.
[b] Baseline accessibility scores calculated using a 2-step floating catchment area.
[c] Simulated accessibility scores calculated using a 30-trial Monte Carlo simulation of a 2-step floating catchment area.
[d] Details on this analysis, including formulas and Python code can be found at https://bit.ly/githubAccessBama.

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ORIGINAL RESEARCH

Racial/Ethnic Disparities Among US Children and Adolescents in Use of Dental Care

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Summary

What is already known about this topic?

Dental care among children has increased over the past decade, and racial/ethnic disparities have narrowed for some groups.

What is added by this report?

We used crude prevalence estimates of dental care use to calculate absolute disparities and changes in disparities. We used multivariate analysis to determine factors associated with changes in disparities from 2001 through 2016. We included Asians, for whom many disparity studies have not had sufficient data.

What are the implications for public health practice?

Our study adds to the few long-term, controlled studies of dental care use by using a national data set representative of US children and adolescents.

Abstract

Introduction

Dental care among children has increased over the past decade, and racial/ethnic disparities have narrowed for some groups. We measured changes in racial/ethnic disparities in annual dental care for children and adolescents aged 2 to 17 years and conducted multivariate analysis to study factors associated with changes in disparities over time.

Methods

We used Medical Expenditure Panel Survey data to obtain crude prevalence estimates of dental care use and calculated absolute disparities and changes in disparities for 3 racial/ethnic groups of children and adolescents compared with non-Hispanic white children and adolescents relative to fixed points in time (2001 and 2016). We pooled all single years of data into 3 data cycles (2001–2005, 2006–2010, and 2011–2016) and used multivariate regression to assess the relationship between dental care use and race/ethnicity, controlling for the covariates of age, sex, parents' education, household income, insurance status, and data cycle (time).

Results

Use increased by 18% only in low-income children and adolescents. Low-income Hispanic (adjusted prevalence ratio [aPR] = 0.98; 95% CI, 0.94−1.02) and Asian (aPR = 0.92; 95% CI, 0.83−1.02) participants showed no difference in dental care use relative to non-Hispanic white participants, but non-Hispanic black participants had significantly lower use (aPR = 0.84; 95% CI, 0.81−0.88). Public and private insurance were associated with a doubling of use among low-income children.

Conclusion

We saw a modest increase in dental care use and a narrowing of disparities for some low-income children and adolescents. Use among low-income Hispanic and Asian participants "caught up" with use among Hispanic white participants but remained well below that of children and adolescents in families with middle and high incomes. Disparities persisted for non-Hispanic black participants at all income levels.

Introduction

Racial and ethnic disparities in children's oral health and their access to dental care have been well documented (1–3). Findings from many studies show the highest use among non-Hispanic white populations and the lowest use among Hispanic and non-Hispanic black populations. Studies have shown an increase in use and some narrowing of racial/ethnic disparities among children and adolescents aged 2 to 17 years, but disparities relative to non-Hispanic white children persist by family income and insurance status (4–7). Studies of national survey data showed that children aged 2 to 17 years had a steady growth in annual dental visits from 1997 through 2010 (7–9). This growth is primarily due to an increase in insured children and a shift from private to public insurance as public insurance programs expanded (10,11). Public health insurance programs covering dental care expanded for low-income children through Medicaid in the 1980s and 1990s and through the enactment of the Children's Health Insurance Program (CHIP) in the 1990s. Publicly funded dental care also expanded through the enactment and reauthorization of the State Children's Health Insurance Program (SCHIP) in 1997 and in 2007 (12–14).

Healthy People 2020, the national framework of more than 1,200 objectives for tracking the health of Americans, focuses on achieving health equity and eliminating disparities. Each objective has a nationally representative data source, a baseline value, and a target to be reached by 2020 (15). One objective of Healthy People 2020 is to increase the proportion of children who make an annual dental visit to 49% by 2020 (16). Changes in disparities can be monitored by using methodology promoted by the Healthy People 2020 program (17–19).

We hypothesized on the basis of past studies that either non-Hispanic black or Hispanic children would have the lowest levels of changes in disparities relative to non-Hispanic white children (4–7). Our first aim was to quantify changes in disparities by using Healthy People 2020 methodology. Our second aim was to determine factors associated with changes in disparities by using multivariate analysis.

Methods

Data source

We analyzed data on 132,763 children by using a subset of 2001–2016 data from the Medical Expenditure Panel Survey–Household Component (MEPS-HC), a nationally representative survey managed by the Agency for Healthcare Research and Quality. MEPS-HC contains information on demographic characteristics, health status, access to care, health insurance coverage, household income, employment status of the head of household, and use of health services. Since 2001, approximately 7,300 to 9,700 children from 13,000 American families have been included in each year of MEPS. This number represents 62.7 to 64.4 million children aged 2 to 17 years in the United States (20). MEPS is conducted by using 5 rounds of in-person interviews with a study participant aged 2½ years or older. MEPS-HC is generally the data source of choice for estimating dental care use and assessing disparities, including assessments in analyses for Healthy People 2020.

Variable definitions

The outcome variable, dental care use, was defined as prevalence as reported by a parent or caregiver of a dental visit or visits at any round of interview during the calendar year assessed with the question, "Since [START DATE]/Between [START DATE] and [END DATE], did [PERSON] see or talk to any type of dental care provider, such as the types listed on this card, for dental care or a dental check–up?" (20).

Race/ethnicities we studied were non-Hispanic white, non-Hispanic black, Hispanic, and Asian, which included Native Hawaiian and other Pacific Islanders. Other covariates were age group (2–4 y, 5–11 y, 12–17 y), sex, parent or guardian's education (<12th grade, 12th grade, >12th grade), annual household income by percentage above the federal poverty level (FPL) (defined as low, <200%; middle, 200–399%; high, ≥400%), medical health insurance status (private, public, uninsured), dental insurance (yes/no), and data cycle (time). Medicaid, CHIP, and SCHIP were included under the public insurance category (20). American Indian and Alaska Native children were excluded from the study because of the small sample size.

Disparities analysis

We defined a disparity as a difference in prevalence of dental care use among a racial/ethnic group relative to non-Hispanic white children. Non-Hispanic white children were selected as the reference group because they have the highest prevalence of dental care use or "most favorable" outcome (17). Disparities were measured by using single-year crude prevalence estimates for 2001 and 2016. An absolute disparity was the arithmetic difference between one group's prevalence and the prevalence among non-Hispanic white children. A measure of change in disparities over time was the percentage-point difference between the absolute disparity at baseline (2001) subtracted from the absolute disparity at the most recent data point (2016) (18). We based tests for significant differences in use between a racial/ethnic group relative to non-Hispanic white children on a 2-sided z test at $P < .05$ level of significance; 95% CIs were calculated for absolute disparities. The unit of measurement for absolute disparity and change in disparity was percentage-point difference.

Bivariate analysis

Data were pooled into 3 data cycles (2001–2005, 2006–2010, and 2011–2016), and cycles were analyzed separately. We described prevalence of population characteristics by race/ethnicity and by dental care use. We based tests of significant differences on a 2-sided t test at $P < .05$ level of significance, and we calculated 95% CIs.

Multivariate analysis

We used logistic regression to study the relationship between the outcome of dental care use and race/ethnicity, controlling for covariates of age, sex, parents' education, household income, insurance status, and data cycle (time). Adjusted prevalence ratios (aPRs) were calculated to quantify changes in use over 3 periods, controlling for other covariates. All analyses took the complex survey design into consideration by using SAS callable SUDAAN 11.0 (RTI International).

Results

Disparities analysis. We found significant differences in our sample of 132,763 children in the prevalence of use among non-Hispanic black children (31.4%), Hispanic children (33.3%), and Asian children (38.1%) compared with non-Hispanic white children (56.8%) ($P < .001$) (Table 1). By 2016, dental care use increased for all groups; however, differences relative to non-Hispanic white children remained significant ($P < .001$). In 2016, all racial/ethnic groups except non-Hispanic black children (44.1%) had reached or surpassed the Healthy People 2020 target of 49%. In 2001, absolute disparities, relative to non-Hispanic white children, were 25.4 percentage points (95% CI, 20.9−29.9) for non-Hispanic black children, 23.6 percentage points (95% CI, 19.9−27.2) for Hispanic children, and 18.8 percentage points (95% CI, 11.8−25.6) for Asian children. In 2016, absolute disparities narrowed significantly for non-Hispanic black children (15.7 percentage points; 95% CI,10.5−20.9), for Hispanic children (9.1 percentage points; 95% CI, 4.0−14.1), and for Asian children (4.7 percentage points; 95% CI, 3.1−12.4). From 2001 through 2016, the measure of change in disparities relative to non-Hispanic white children showed significant decreases for non-Hispanic black children (−9.7 percentage points, $P = .006$), Hispanic children (−14.4 percentage points, $P < .001$), and Asian children (−14.1 percentage points, $P = .008$). Non-Hispanic black children had the lowest change in disparities.

Bivariate analysis

Population characteristics by race/ethnicity. Non-Hispanic white and Asian children had similar high proportions of parents or guardians with more than a 12th-grade education, high annual incomes, and private health insurance. In all racial/ethnic groups, the proportions of children with private health insurance and dental insurance decreased over time while the proportions with public health insurance increased. Non-Hispanic black children and Hispanic children had the greatest increase in public health insurance.

Prevalence of dental care use by population characteristics. From the first data cycle (2001–2005) to the third data cycle (2011–2016), a slight but significant increase occurred in the proportion of children using dental care (Table 2). At each data cycle, non-Hispanic white children had the highest use, whereas Asian children's use fell between that of non-Hispanic white children and the other groups. We saw significant increases in percentage of use from 2001 to 2016 for non-Hispanic black children, from 36.8 % (95% CI, 35.0%–38.7%) to 44.4% (95% CI, 42.6%–46.2%); Hispanic children, from 36.2% (95% CI, 34.6%–37.8%) to 47.9% (95% CI, 46.3%−49.5%); and Asian children, from 43.2% (95% CI, 39.4%−47.0%) to 52.0 (95% CI, 48.2%−55.7%). Non-Hispanic white children had no significant increase. In addition, significant increases in use were found among children with parents or guardians at the lowest education level ($P < .001$), among low-income children ($P < .001$), and among publicly insured children ($P < .001$).

Multivariate analysis

The sample for our multivariate analysis was 128,141 children. The decrease from 132,763 in sample size used in the bivariate analysis was due to missing data on parent or guardian's education. We cross-tabulated private health insurance and private dental insurance by using a subset of 2005 data for 8,755 children. Among the 3,266 of those children with dental insurance, 98% had private health insurance, and among 4,122 children with private health insurance, 77.7% had dental insurance. Because of the high correlation between private dental insurance and private health insurance (R = 0.72, Pearson correlation coefficient), dental insurance was excluded as a covariate in the multivariate analysis. This decision was further supported by an assessment of multicollinearity that showed large variance proportions (greater than 0.5) for health (0.82) and dental (0.72) insurance.

We ran the same model for low-, medium-, and high-income levels, because household income modified the effect of race/ethnicity on dental care use. After we controlled for covariates, non-Hispanic black children had lower use than non-Hispanic white children at all income levels (low income, aPR = 0.84 [95% CI, 0.81−0.88]; middle income, aPR = 0.79 [95% CI, 0.75−0.83]; and high income, aPR = 0.80 [95% CI, 0.75−0.85]) (Table 3). Low-income Hispanic children (aPR = 0.98; 95% CI, 0.94−1.02) and low-income Asian children (aPR = 0.92; 95% CI, 0.83−1.02) showed no difference in use relative to non-Hispanic white children. The only group that showed a significant increase in use over time was low-income children of all race/ethnicities. Using the first data cycle as a reference (2001−2005) showed that use increased significantly by 8.0% in the second data cycle (aPR = 1.08; 95% CI, 1.03−1.13) and increased significantly by 18% in the third data cycle (aPR = 1.18; 95% CI, 1.12−1.24).

The association between dental care use and public health insurance compared with no insurance varied by income (low income, aPR = 2.20 [95% CI, 1.97−2.47]; middle income, aPR = 1.53 [95% CI, 1.37−1.70]; and high income, aPR = 1.15 [95% CI, 1.01−1.31]). We found similar results with children with private health insurance compared with those who were uninsured (low income, aPR = 2.23 [95% CI, 1.99−2.50]; middle income, aPR = 1.68 [95% CI, 1.53−1.84]; and high income, aPR = 1.29 [95% CI, 1.17−1.42]).

Discussion

The Healthy People 2020 methodology provides a straightforward way of monitoring changes in disparities. By using the 2001 baseline prevalence, future changes in disparities can be easily assessed as subsequent years of crude use estimates from MEPS data are released. Our data on disparities and multivariate analyses showed the same result, that non-Hispanic black children made the least progress in reducing disparities relative to non-Hispanic white children. This result supported our hypothesis that either non-Hispanic black children or Hispanic children would have lower dental care use and the lowest changes in disparities relative to non-Hispanic white children. Hispanic children showed more progress than non-Hispanic black children in disparities reduction relative to non-Hispanic white children. However, the overall reduction in disparities was small and occurred only in the low-income group. Notably, disparities persisted for non-Hispanic black children at all income levels and for Hispanic and Asian children at middle- and high-income levels. Compared with non-Hispanic white children, Asian children had persistently lower use at middle- and high-income levels despite being similar to non-Hispanic white children in characteristics that positively influence dental care use, including high levels of parent or guardian's education, household income, and private insurance. Our finding of lower use among Asian children was confirmed in a 2003−2004 national survey, which cited contributing factors as parents' reports of problems obtaining specialty care and reports that the dentist did not know how to provide care (6). Several previous studies showed that expansion of public insurance for low-income children helped reduce disparities (5,7,11,21). Our findings showed that health insurance was 1 factor that positively influenced use, and its influence was greater for low-income children than for middle- and high-income children. Our study was not designed to directly assess the role of insurance in reduction of racial/ethnic disparities. However, the disparity reduction observed in our study may have been associated with the increase in the proportion of low-income children covered by public insurance over the study's duration. Coverage with private insurance did not significantly increase from 2001 through 2016. Prevalence ratios were similar for the association of public and private health insurance with increased use compared with no health insurance, which highlights the importance of both types of insurance.

Another of our findings confirmed by previous studies was that disparities persisted and could not be explained by the variables available in the MEPS data set, including traditional sociodemographic factors or insurance (5,8,10). Persistent disparities could be explained by racial differences in oral health literacy, language, acculturation, and perception of need (2,22,23). Oral heath literacy is the ability to understand basic oral health information and the health care system to make appropriate health decisions. Low oral health literacy has been associated with a greater level of racial/ethnic disparities in oral health (22). Policy issues, such as dentist participation in public insurance programs, low reimbursement rates for public programs, and cost sharing can also limit access to dental services among uninsured and publicly insured children (13,23).

Differences in results between our study and previous multiyear, controlled analyses of national data are found in the magnitude of disparity reduction in our study and in the magnitude of persistent disparities. A controlled study of the 1964–2010 National Health Interview Survey (NHIS) data found that disparities in dental care use among non-Hispanic black relative to non-Hispanic white children were large and significant in 1996 but attenuated and became nonsignificant by 2010 (8). Our finding in MEPS data of persistent disparities between non-Hispanic black and non-Hispanic white children is not consistent with the findings in NHIS data. This inconsistency can be explained by differences in methodology in national surveys, resulting in different estimates of prevalence of dental care use (24). A 2001–2010 MEPS study using a decomposition regression analysis found dental care use relative to non-Hispanic white children increased to a greater extent for non-Hispanic black than for Hispanic children (10). In contrast, our study found that use relative to non-Hispanic white children increased to a greater extent for Hispanic than for non-Hispanic black children with low incomes. Variation in methodology in studies using the same data set can lead to different conclusions about how and why disparities have changed; therefore, it is important to study disparities with multiple methods (25). Another possible explanation for differences between our study and the 2001–2010 MEPS study is that we used more recent data.

Our study has limitations. MEPS is a cross-sectional survey, so we were unable to infer causality. The results in our study are based on self-reported data, which could result in some social desirability or recall bias for dental care use, even though MEPS ascertains dental visits over a relatively short term (within 3 to 4 months) compared with other national surveys (within 1 year) (24). Our study had no measure of oral health status or perceived need for care, which are important predictors of use. Another limitation was our use of health insurance as a proxy for dental insurance. One-third of children with private health insurance did not have dental insurance and likely had lower use than those with dental insurance. This difference may have resulted in a bias to the null in the association between use and private health insurance.

Our study showed a modest increase in dental care use and narrowing of disparities for some low-income children. Use by low-income Hispanic and Asian children caught up with non-Hispanic white children. Nevertheless, progress has been minimal, because use in all low-income children remains well below that of middle- and high-income children. Disparities persisted for non-Hispanic black children at all income levels. Insurance appeared to be an important factor but did not eliminate disparities. It is important to continue to monitor progress in disparities reduction.

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Tables

Table 1. Crude Prevalence of Dental Care Use, Absolute Disparity, and Change in Disparity Among US Children and Adolescents Aged 2–17 Years, by Race/Ethnicity, Medical Expenditure Panel Survey, 2001 and 2016[a]

Variable	Prevalence of Use, 2001, % (95% CI)	Prevalence of Use, 2016, % (95% CI)	Absolute Disparity in 2001[b], Percentage Point (95% CI)	*P* Value	Absolute Disparity in 2016[b], Percentage Point (95% CI)	*P* Value	Change in Disparity from 2001 to 2016[c], Percentage Point (95% CI)	*P* Value
Sample size, n	8,242	8,520	—	—	—	—	—	—
All	47.8 (46.0–49.6)	54.8 (52.8–56.8)	—	—	—	—	—	—
Race/ethnicity								
Non-Hispanic white	56.8 (54.4–59.2)	59.8 (56.8–62.8)	Reference		Reference		Reference	
Non-Hispanic black	31.4 (28.0–34.9)	44.1 (40.4–47.9)	25.4 (20.9–29.9)	<.001	15.7 (10.5–20.9)	<.001	−9.7	.006
Hispanic	33.3 (30.3–36.4)	50.7 (47.7–53.8)	23.6 (19.9–27.2)	<.001	9.1 (4.0–14.1)	<.001	−14.4	<.001
Asian	38.1 (30.8–45.9)	55.2 (48.8–61.3)	18.8 (11.8–25.6)	<.001	4.7 (3.1–12.4)	.238	−14.1	.008

Abbreviations: —, not applicable.
[a] Healthy People 2020 target for prevalence in dental care use is 49%.
[b] Absolute disparity is percentage-point difference in prevalence of use between non-Hispanic white and other groups: 56.8%−31.4% = 25.4 (non-Hispanic black in 2001).
[c] Change in disparity is percentage-point difference in absolute disparity at most recent data point subtracted from absolute disparity at baseline data point: for example, 15.7−25.4 = −9.7 (for non-Hispanic black children and adolescents in 2001–2006).

Table 2. Prevalence of Dental Care Use by Population Characteristics (Weighted Proportions), US Children Aged 2–17 Years (N = 132,763), by Data Cycle (2001–2005, 2006–2010, and 2011–2016), Medical Expenditure Panel Survey, 2001 and 2016

Variable	2001–2005 Use, % (95% CI)	2006–2010 Use, % (95% CI)	2011–2016 Use, % (95%CI)	*P* Value for Change From 2001–2005 to 2011–2016
Eligible sample size, n	43,760	39,744	49,259	—
Proportion with ≥1 visit	50.1 (49.0–51.2)	50.8 (49.7–51.9)	53.5 (52.3–54.8)	<.001
Race/ethnicity[a]				
Non-Hispanic white	58.3 (56.8–59.7)	56.9 (55.4–58.4)	58.8 (57.0–60.5)	.66
Non-Hispanic black	36.8 (35.0–38.7)	41.9 (40.0–43.7)	44.4 (42.6–46.2)	<.001
Hispanic	36.2 (34.6–37.8)	41.5 (39.9–43.1)	47.9 (46.3–49.5)	<.001
Asian	43.2 (39.4–47.0)	48.1 (43.0–53.6)	52.0 (48.2–55.7)	.001
Age, y				
2–4	26.5 (25.0–28.0)	29.7 (28.1–31.4)	34.4 (32.6–36.2)	<.001
5–11	56.3 (54.9–57.7)	56.5 (55.0–57.9)	58.0 (56.5–59.5)	.09
12–17	54.3 (52.9–55.7)	54.9 (53.4–56.4)	57.6 (55.9–59.2)	.002
Sex				
Male	49.0 (47.8–50.2)	49.6 (48.3–51.0)	52.7 (51.2–54.1)	<.001
Female	51.2 (49.9–52.6)	52.1 (50.8–53.4)	54.5 (53.1–55.8)	<.001
Parent or guardian's education				
<12th grade	30.4 (28.6–32.1)	36.8 (34.7–38.9)	42.7 (40.6–44.8)	<.001
12th grade	42.5 (40.9–44.0)	42.2 (40.4–44.0)	44.9 (42.9–46.8)	.05
>12th grade	59.8 (58.5–61.2)	57.8 (56.4–59.1)	58.3 (56.9–59.7)	.14
Annual household income[b]				
Poor/low income	36.0 (34.9–37.1)	39.7 (38.4–41.1)	44.9 (43.5–46.4)	<.001
Middle income	51.3 (49.5–53.1)	51.9 (50.4–53.5)	54.1 (52.3–55.9)	.03
High income	67.7 (66.0–69.3)	65.7 (63.6–67.7)	66.1 (64.2–68.0)	.14
Health insurance				
Any private	57.7 (56.5–59.0)	57.9 (56.5–59.3)	60.1 (58.5–61.6)	.03
Public only	37.4 (35.9–38.9)	41.6 (40.0–43.2)	46.3 (44.9–47.8)	<.001
Uninsured	26.2 (23.4–29.2)	29.1 (25.9–32.5)	28.7 (24.9–32.9)	.403
Dental insurance				
Any	58.2 (56.8–59.6)	59.1 (57.5–60.6)	61.0 (59.4–62.6)	.02
None	41.6 (40.3–42.9)	43.5 (42.2–44.8)	47.3 (46.0–48.6)	<.001

Abbreviation: —, not applicable.
[a] All tests for differences in dental care use between a racial/ethnic group and non-Hispanic white children and adolescents were significant based on a 2-sided *t* test at $P < .05$ level of significance.
[b] Defined as percentage of federal poverty level: low income, <200%; middle income, 200%–399%; high income, ≥400% (1).

Table 3. Adjusted Prevalence Ratio Estimates for Factors Associated With Dental Care Use Among US Children and Adolescents Aged 2–17 Years (N = 128,141)[a], by Income Level[b], Using Pooled Years of Data (2001–2005, 2006–2010, 2011–2016), Medical Expenditure Panel Survey, 2001 and 2016

Variable	Low Income, aPR (95% CI)	Middle Income, aPR (95% CI)	High Income, aPR (95% CI)
No. of observations used in analysis	72,893	33,414	21,834
Age, y			
2–4	1 [Reference]	1 [Reference]	1 [Reference]
5–11	1.70 (1.61–1.79)[c]	2.12 (2.01–2.24)[c]	1.97 (1.86–2.07)[c]
12–17	1.59 (1.51–1.68)[c]	2.06 (1.95–2.18)[c]	1.98 (1.87–2.09)[c]
Sex			
Male	1 [Reference]	1 [Reference]	1 [Reference]
Female	1.06 (1.03–1.08)[c]	1.04 (1.02–1.07)[c]	1.02 (1.00–1.05)
Race/ethnicity			
Non-Hispanic white	1 [Reference]	1 [Reference]	1 [Reference]
Non–Hispanic black	0.84 (0.81–0.88)[c]	0.79 (0.75–0.83)[c]	0.80 (0.75–0.85)[c]
Hispanic	0.98 (0.94–1.02)	0.87 (0.84–0.91)[c]	0.85 (0.81–0.89)[c]
Asian	0.92 (0.83–1.02)	0.79 (0.73–0.86)[c]	0.82 (0.78–0.88)[c]
Parent or guardian's education			
<12th grade	1 [Reference]	1 [Reference]	1 [Reference]
12th grade	1.10 (1.05–1.14)[c]	1.05 (0.97–1.14)	1.02 (0.87–1.19)
>12th grade	1.23 (1.17–1.29)[c]	1.30 (1.21–1.40)[c]	1.25 (1.07–1.45)[c]
Health insurance			
Uninsured	1 [Reference]	1 [Reference]	1 [Reference]
Any private	2.23 (1.99–2.50)[c]	1.68 (1.53–1.84)[c]	1.29 (1.17–1.42)[c]
Public only	2.20 (1.97–2.47)[c]	1.53 (1.37–1.70)[c]	1.15 (1.01–1.31)[c]
Data cycle			
2001–2005	1 [Reference]	1 [Reference]	1 [Reference]
2006–2010	1.08 (1.03–1.13)[c]	1.00 (0.97–1.05)	0.97 (0.94–1.01)
2011–2016	1.18 (1.12–1.24)[c]	1.02 (0.98–1.07)	0.98 (0.94–1.01)

Abbreviations: aPR, adjusted prevalence ratio.
[a] Total study participants was 132,763; however, only 128,141 had data on parents' education.
[b] Income defined as percentage of federal poverty level: low income, <200%; middle income, 200%–399%; high income, ≥400% (1).
[c] Indicates significant at $P < .05$.

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ORIGINAL RESEARCH

Oral Health Behaviors in Very Young Children in Low-Income Urban Areas in Chicago, Illinois, 2018–2019

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PEER REVIEWED

Summary

What is already known on this topic?

Health disparities are well documented in the prevalence of and morbidity associated with dental caries, the most common chronic disease of childhood.

What is added by this report?

Most data on oral health risk and behaviors do not include infants and toddlers. We describe the oral health behaviors of children younger than 3 years and identify areas for intervention.

What are the implications for public health practice?

Behaviors established during early childhood set the trajectory for a lifetime. This analysis shows the importance of the family unit and social support in efforts to improve oral health outcomes for high-risk children.

Abstract

Introduction

Because most data on oral health do not include infants and toddlers, we aimed to describe the oral health behaviors of low-income children younger than 3 years and determine factors associated with child tooth brushing.

Methods

We obtained data from the Coordinated Oral Health Promotion Chicago study, which included 420 families with children aged 6 to 36 months and their caregivers in Cook County, Illinois. We assessed child frequency of brushing from caregiver reports and objectively determined child dental plaque scores. Significant factors associated with tooth brushing frequency and dental plaque score were identified using the Least Absolute Shrinkage and Selection Operator variable selection.

Results

Mean child age was 21.5 (SD, 6.9) months, and only 45% of caregivers brushed their children's teeth twice per day or more. The mean plaque score was 1.9 (SD, 0.6), indicating high levels of plaque. Child brushing frequency was higher when children were older; used the correct toothpaste amount; brushed for a longer duration; and when caregivers brushed their own teeth more frequently, had more help with the overall care of the child's teeth, and had family to help. Child brushing frequency was lower for caregivers with more interference from activities of daily life. Children whose caregivers had more adult help with child brushing had better plaque scores; worse plaque scores were seen in children with higher sugary beverage and food consumption and lower household incomes.

Conclusion

The tooth brushing behaviors of young children are strongly associated with those of their parents and with the level of family support for brushing. Interventions to improve brushing in young children should focus on the entire family.

Introduction

Dental caries is the most common chronic disease of childhood, affecting over half of US children aged 6 to 8 years (1). Although treatment of caries leads to significant direct health care costs, the true costs extend beyond the health care setting. Caries is associated with impaired cognitive development, increased school absenteeism, worse school performance, increased missed work for parents, and worse quality of life (2–4). Oral health disparities are well documented, and low-income minority children experience the highest prevalence and illness from caries (5–8).

Caries risk is influenced by many factors over the life course beginning during the prenatal period (9). Most data on oral health risk and behaviors do not include infants and toddlers, even though these formative years determine the trajectory for children's oral health (10). The largest health survey in the United States, the National Health and Nutritional Examination Survey (NHANES), captures oral health behaviors data only for children aged 3 years or older. Also lacking is a complete understanding of oral health risk factors in very young children and a reliable model to predict future caries in children. Although many of these risk factors are well documented (eg, low fluoride exposure, limited access to dental care, overconsumption of sugar-sweetened beverages) (11,12), the frequency of exposure to these risk factors in children younger than 3 years is unknown. This lack of data makes it challenging to prospectively identify children who will develop caries and become high users of tertiary oral health services such as emergency departments, urgent care clinics, and operating rooms for oral care.

In addition to limited information on oral health risk factors for children younger than 3, information on the frequency and facilitators of protective oral health behaviors in this age group is also lacking. Major health promotion efforts have been implemented to educate primary care providers and families about these protective behaviors (13,14). One of the primary recommendations is twice-daily tooth brushing with fluoridated toothpaste, shown to be a low-cost clinically effective means of reducing caries for dentate children (15). Chronic conditions such as childhood obesity and diabetes have resulted in an increased awareness of the need to reduce sugar-sweetened beverages and high-sugar foods. There is a growing emphasis on the age 1 dental visit and increased coverage for private and publicly funded dental programs (16–18). Although access to dental care theoretically has improved with expanded programs and Medicaid coverage, many barriers to accessing care persist because dental coverage does not equate to use of dental care (7). Whether increased awareness of brushing and dietary recommendations translates to more adoption of these behaviors in young children is also unknown.

To effectively implement preventive interventions to establish healthy oral care behaviors, we must first characterize the baseline oral health behaviors of young children and identify factors associated with these behaviors. The Coordinated Oral Health Promotion (CO-OP) Chicago study included 420 children aged 6 to 36 months and their primary caregivers. In this analysis we describe the children's oral health behaviors and determine factors associated with child tooth brushing, captured as caregiver-reported brushing frequency, and observed dental plaque.

Methods

Data were obtained from the baseline sample (N = 420 child/caregiver dyads) of the CO-OP Chicago study with the National Institute of Dental and Craniofacial Research's Oral Health Disparities Consortium (19). To qualify, families needed to have a child aged 36 months or younger with at least 2 fully erupted central maxillary incisors. Children also had to receive medical care or services at one of the partnering Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) centers or pediatric medical clinics serving low-income communities in Cook County, Illinois. Families were excluded if their primary language was not English or Spanish, the child did not live with the primary caregiver 5 days per week or more, or the child had medical conditions that interfered with routine tooth brushing. Participants were recruited by research assistants (RAs) in the 20 partnering clinics and WIC centers from January 2018 through February 2019. Families that met inclusion criteria were scheduled for an enrollment visit where the baseline data collection occurred (19).

Caregivers provided written informed consent and parental permission at the start of the enrollment visit. Child assent was waived because of child age. Institutional review boards at the University of Illinois at Chicago, the University of California San Francisco, and the Chicago Department of Public Health approved the study.

Data collection was conducted mainly in homes by paired RAs using standardized methods established by the research team (19). RAs first administered a verbal questionnaire using prompt cards that asked about the child's and caregiver's oral health behaviors and beliefs, other health conditions, access to care, psychosocial factors, and demographics. Child and caregiver oral health quality of life was captured using the Early Childhood Oral Health Impact Scale (ECOHIS) and Oral Health Impact Profile, respectively. Caregiver quality of life (referred to as "social functioning"), depression, anxiety, and social support were measured using Patient-Reported Outcomes Measurement Information System (PROMIS) measures. Family functioning was assessed using the Confusion, Hubbub, and Order Scale (CHAOS). RAs took photographs of the child's teeth before and after the application of plaque disclosing solution using a standardized protocol. At the end of the visit, caregivers were asked to demonstrate how the child's teeth are typically brushed. RAs used checklists to systematically capture duration of brushing, supplies used (eg, toothbrushes, mouthwash, floss), and parent involvement. Data were entered directly into the study's Research Electronic Data Capture (REDCap) database. Calibrated dental clinicians, including a board-certified pediatric dentist and a registered dental hygienist, later reviewed images in the research office and scored them for plaque using the Oral Hygiene Index–Maxillary Incisor Simplified (OHI-MIS) scale. The OHI-MIS scale is a modification of the Simplified Oral Hygiene Index; the adaptions allow for plaque scoring using photographs in children with an incomplete primary dentition (20). Plaque scores of less than 0.7 are considered "good," 0.7–1.8 are "fair," and 1.9–3.0 are "poor" (21).

Analyses

Demographic characteristics of children and caregivers, as well as the frequency of tooth brushing and plaque scores, were reported using counts (percentages) or mean and SD for categorical variables and median and interquartile range for continuous variables. Frequency of brushing was recoded as a continuous variable, and variables with 5 or more ordinal categories were also recoded as continuous measures. Thirty-two variables were considered in the analyses based on a priori–determined potential for influence on the primary outcomes. Pair-wise correlations for most covariates were low, with few correlations being in the moderate range, specifically among the PROMIS measures ($\rho < 0.80$). The 2 primary outcome measures, child frequency of brushing and plaque score, were correlated at −0.11, $P = .02$. Some variables had missing values. Of 420 participant records, 369 (87.9%) had complete observational data. Variables describing observed toothpaste amount, type of toothpaste, and length of observed brushing had the most missing data points (47–48 cases, 11.2%–11.4%) due mainly to parent or child refusal of the brushing demonstration. Responses were coded as "not applicable" for some variables. For example, if a child had not yet started brushing, toothpaste use would be coded as not applicable. Those responses were then recoded as no for analysis. Household income was reported as unknown by 52% of participants, which was expected for the population. Consequently, income was used as a categorical variable, with "unknown" as a category.

The selection of significant factors associated with the 2 outcomes (frequency of tooth brushing and plaque score) was performed using the Least Absolute Shrinkage and Selection Operator (LASSO) variable selection. The LASSO is a shrinkage estimator with a variable selection. The estimator shrinks regression coefficients of some of the variables to zero, hence selecting essential variables. The penalty parameter lambda determining feature selection was chosen by tenfold cross-validation to minimize predicted mean-squared error. Model averaging is a technique based on the empirical distribution of the statistics resulting from the resampling of the original population with a replacement. We used 2-step model averaging. In the first step, the model selection using LASSO shrinkage was repeated for 1,000 samples. The procedure allowed for ranking of variable importance by reporting the percentage of time that a variable was selected into the model. This first step of model averaging produced a model that contained a large number of effects. The second step of the model averaging (ie, refitting) was used to obtain a more parsimonious model by specifying the percentage of cut-point of effects retained in the final model. After a more parsimonious model was identified, a least-squares model was fit with no effect selection on 1,000 samples with replacement, which produced an empirical distribution of the regression coefficients on which the importance of the variables was based. Because standard inference does not properly consider the model selection process in LASSO, model averaging is the preferred method to interpret the standard error of the model estimates (22). The list of essential factors for both outcomes is reported using 20% and 40% frequency selection. The lower percentage was less restrictive and allowed more variables into the model. Based on the empirical distribution, the mean value of regression coefficients with a 90% confidence interval was reported as the final model results. All statistical analyses were done by using SAS 9.4 (SAS Institute).

We also tested a full linear model, allowing all 32 variables to be present, which represented the least-biased parameter estimates. All models controlled for partnering site using a set of indicator variables. The caregiver, child, and household demographic characteristics and children's brushing behaviors are described elsewhere (19).

Results

The mean child age was 21.5 (SD 6.9) months, and 50.7% of children were female. Almost all children had health insurance (95.5%), which was mainly Medicaid (89.3%). Most caregivers were female (96.4%) and the biological parent (96.4%); the rest were other relatives or foster parents. Parents described themselves primarily as Black race (41.9%) or Hispanic ethnicity (52.1%). More than half reported some education after high school (52.4%), 31.4% had a high school degree or GED, and 16.2% had less than a high school education. Sixty-one percent of caregivers lived with a partner or spouse. Caregivers reported their overall health as "excellent/very good" (40.5%), "good" (39.8%), or "fair/poor" (19.8%). Caregivers reported much worse social functioning (mean *t*-score, 32.0 [SD, 6.9]) than the reference population (mean *t*-score, 50 [SD, 10]). Caregiver anxiety and depression symptoms were slightly lower than the reference population means (mean *t*-score, 46.6 [SD, 8.1] and mean *t*-score, 46.2 [SD, 6.9], respectively).

Only 25 (6.0%) caregivers had not started brushing or wiping their children's teeth. For the rest, 45.0% brushed their children's teeth twice per day or more, 33.8% once per day, and 15.2% brushed sometimes but not every day. The mean OHI-MIS plaque score was in the range of "poor" at 1.9 (SD 0.6); 54.9% scored 1.9 or higher. Most caregivers did all the brushing during observations without active child participation (6.2%). Most children (74.3%) had a child-sized toothbrush, and 52.3% used toothpaste with fluoride. Some children rinsed with water (36.0%) and/or spit (25.3%) after brushing.

Caregivers reported high oral health knowledge (mean, 4.2 [SD 0.8]), and social support was comparable to reference population means (Table 1). Half of the caregivers reported that the activities of daily life never made it difficult to care for their child's teeth, although 26.0% of caregivers never or rarely had help caring for their children's teeth. More than half of children (59.7%) had never been to the dentist. Exclusively drinking purchased bottled water was the most common response for drinking water source (54.6%). Exposure to sugary beverages was common, with 28.8% saying their children consumed sugary beverages once per day and 37.2% consuming sugary beverages twice per day or more. Caregivers reported major oral health challenges of their own; 56.4% said their mouth and teeth were in "fair" or "poor" condition. One quarter (25.7%) brushed less than twice per day, and 43.2% had not been to a dentist in over a year. The main reasons for caregivers not getting needed dental care in the past year were related to cost and insurance coverage.

Tables 2 and 3 present the results of multiple linear models without selection (full models) and the variables selected using LASSO regularization from the 32 potential associated factors, controlling for partner sites. The overlap in variables identified as important between the full models and LASSO regularization indicates low confounding and multicollinearity between variables. The LASSO 20% frequency selection shows the less restricted model, which allowed more variables to remain. The important factors for frequency of child tooth brushing identified by the more restrictive LASSO regularization with a 40% threshold to be retained in the final model included 8 variables, 7 of which met significance at the 10% level. Child brushing frequency (Table 2) was higher when children were older (mean β = 0.014; 90% CI, 0.006 to 0.022); used the correct toothpaste amount (mean β = 0.115; 90% CI, 0.004 to 0.221); brushed for a longer duration (mean β = 0.001; 90% CI, 0.000 to 0.002); and when caregivers brushed their own teeth more frequently (mean β = 0.397; 90% CI, 0.299 to 0.490), had more help with the overall care of the child's teeth and child brushing (mean β = 0.058; 90% CI, 0.021 to 0.096), and had family or a partner to help care for the child's teeth (mean β = 0.292; 90% CI, 0.229 to 0.354). Child brushing frequency was lower for caregivers with more brushing interference from activities of daily life (mean β = −0.105; 10% CI, −0.161 to −0.048).

With regard to plaque score, children whose caregivers had more help from other adults with brushing their child's teeth had better plaque scores (mean β = −0.092; 90% CI, −0.156 to −0.028) (Table 3). Higher plaque scores were seen in children with higher sugary beverage consumption (mean β = 0.014; 10% CI, 0.006 to 0.022), higher sweet or sugary food consumption (mean β = 0.009; 90% CI, 0.001 to 0.017), and lower household incomes (mean β = 0.153; 90% CI, 0.036 to 0.268).

Discussion

We identified multiple factors associated with tooth brushing behaviors and dental plaque in low-income children aged 36 months or younger, and these findings are relevant because dental caries begins early. The consistency in selecting the same set of factors between the full and LASSO regularization models highlights the robustness of the selection procedure in identifying meaningful factors associated with the frequency of tooth brushing and plaque score for this population.

Data from 2011–2016 reported a caries prevalence of 23% in US children aged 2 to 5 years, and this prevalence doubled by elementary school (1). In Illinois, overall caries and untreated caries prevalence have repeatedly surpassed national rates and disproportionately impact low-income, non-Hispanic Black, and Hispanic children (23). The participants in our analyses represent this high-risk demographic category. Identification of early risk and protective factors is essential to reduce oral health disparities and prevent or slow caries development in children.

The most influential factors associated with child brushing frequency in our analyses were the caregiver's own brushing frequency and caregivers having assistance with brushing from others. These associations are consistent with findings from other studies (24–26). Caregivers that brush their own teeth are more likely to brush their children's teeth as well (26). This association may be driven by caregiver oral health literacy, an overall value on oral hygiene within the family, established household routines, or by the fundamental principle that children learn from imitating adults (27). Having additional caregivers assist with child tooth brushing was associated with both higher brushing frequency and lower plaque scores. This points to the critical need for more family support for child brushing at this young age, mainly because children do not have the knowledge or manual dexterity to brush their teeth independently until they are much older. Caregivers have a fixed amount of time to complete necessary tasks, such as those conducted as part of morning or evening routines. When additional caregivers are available to assist with these tasks, children are more likely to receive assistance or supervision with an oral health regimen. Our findings emphasize the importance of the family unit or household, as everyone plays an important role in encouraging and directly supervising a child's tooth brushing.

The frequency of consumption of sugary foods and beverages was associated with worse plaque scores. This finding may be because parents that give more sugary beverages may demonstrate other unhealthy behaviors such as brushing less frequently or effectively. Households that rely on calorie-dense, readily available foods may do so out of necessity and not have the capacity or support to implement regular brushing routines. This finding is concerning because the frequency of exposure to sugar-sweetened foods and beverages is a significant risk factor for dental caries via acidogenic bacteria in plaque (28).

Finally, children in the lowest income category had the highest levels of plaque. Although most of our sample was low-income, worse outcomes in the lowest income level are not surprising. Low-income caregivers have repeatedly reported significant barriers to accessing dental care for their children (29), and these results are compounded by the lack of providers that accept Medicaid, as well as limited case management resources. The overall rate of providers enrolled with Medicaid in the Chicago area is high compared with the rest of the state, mirroring the geographic density of Illinois's population. Unfortunately, enrollment as a Medicaid provider does not mean these dentists serve a significant number of patients on Medicaid. The reality is that many of these providers take only a small number of Medicaid patients and may not perform restorative procedures.

What was surprising were the many factors not associated with brushing behaviors, including access to dental care, caregiver quality of life, social functioning, and caregiver oral health knowledge. Research indicates that children's dental care usage behaviors were associated with their caregivers' behaviors in these areas; children were more likely to have used dental care within the past year when their parents also used dental services (23,25). A possible explanation for the lack of association between dental care use and child brushing behaviors is that most of our sample had the same insurance, limiting variability. Research shows that the overall physical and psychological health and functioning of caregivers influences how they care for the health of their children; poor health, adversity, and inequality accumulate over the life course and across generations (30). Our study did not show differences in behaviors associated with caregiver quality of life and mental health, which may have been because of a lack of variability in the sample, instrument limitations, or perhaps not-yet-identified resilience factors. Finally, uncooperative child behavior is common in toddlers and poses a barrier to tooth brushing, even when caregiver knowledge and intent are good.

Our study has limitations. Because the data were cross-sectional, causation and potential directionality of effects cannot be established. We also did not measure all modifiable factors that influence oral health behaviors. The sample was limited to 1 densely populated urban county in the Midwest, and families had similar economic and races/ethnicities, which limits generalizability. Tooth brushing frequency was caregiver-reported because of the challenges of objectively measuring this behavior in young children, raising the potential for social desirability bias and data inaccuracy. However, we compared our self-reported data to data from other studies, including NHANES, and our results were similar (19). We also added a second measure of brushing — plaque score — to objectively capture the adequacy of brushing behaviors.

Our results indicate the necessity of interventions that target adult assistance with child brushing and reduction of sugary beverages and snack consumption among very young children. Similar to results in older children, our results demonstrate that brushing behaviors of young children are strongly associated with those of their parents and the level of family support for brushing. Interventions to improve brushing in young children should focus on the entire family, encouraging healthy oral health behaviors for parents as well as children. Clinicians and educators should also consider asking about family routines and supports parents have for brushing their children's teeth and offering appropriate interventions when problems are identified. Because low-income urban children are at high risk for developing caries beginning at a very early age, research is needed to determine whether these risk factors are also associated with caries development over time. We should also continue to develop and test interventions that will translate into improved oral health behaviors and outcomes for children.

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Tables

Table 1. Oral Health Risk Factors of Children Aged 6 to 36 Months (N = 420),[a] Coordinated Oral Health Promotion Chicago Study, Chicago, Illinois, 2018–2019

Risk Factor	Value
Caregiver Oral Health	
Condition of mouth and teeth (n = 419)	
Very good	30 (7.2)
Good	153 (36.5)
Fair	175 (41.8)
Poor	61 (14.6)
Frequency of brushing	
Sometimes, but not every day	6 (1.4)
Once per day	102 (24.3)
Twice per day	254 (60.5)
More than twice per day	58 (13.8)
Time since last dentist visit (n = 419)	
Never have been	4 (1.0)
≤6 months	157 (37.5)
>6 months but ≤1 year	77 (18.4)
>1 year but ≤2 years	83 (19.8)
>2 years	98 (23.4)
Main reason for last dentist visit (n = 416)	
Went in on own	218 (52.4)
Something was wrong	138 (33.2)
Other	60 (14.4)
Could not get dental care in the past 12 months (n = 137)	
Could not afford	23 (16.8)
No insurance	32 (23.4)
Insurance did not cover	45 (32.8)
Pregnant	16 (11.7)
Other	21 (15.3)
Child Risk Factors	
Caregiver's/adult's help with brushing	
Child does not brush	25 (6.0)
Child brushes alone	11 (2.6)
Sometimes/most of the time	151 (36.0)
Always	233 (55.5)
Length of time since child's last dental visit (n = 419)	
Never has been	250 (59.7)

[a] Values are no. (%), unless otherwise indicated; N = 420 unless otherwise indicated.
[b] The Oral Health Knowledge Scale was developed by the Knowledge and Behavior Workgroup of the Early Childhood Caries Collaborating Centers (31).

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(continued)

Table 1. Oral Health Risk Factors of Children Aged 6 to 36 Months (N = 420),[a] Coordinated Oral Health Promotion Chicago Study, Chicago, Illinois, 2018–2019

Risk Factor	Value
≤6 months	139 (33.2)
>6 months but ≤2 years	30 (7.2)
Child needed dental care but could not get, past 12 months	31 (7.4)
Type of drinking water (n = 416)	
Purchased only	227 (54.6)
Tap only	73 (17.5)
Both purchased and tap	116 (27.9)
Frequency of sugary beverage consumption	
Rarely or never	74 (17.6)
Once per week, not daily	69 (16.4)
Once per day	121 (28.8)
Twice per day	83 (19.8)
Three times per day or more	73 (17.4)
Child 15 months or older and still drinks from bottle (n = 341)	137 (40.2)
Caregiver Knowledge, Support, and Barriers	
Caregiver knowledge, mean (SD)[b]	4.2 (0.8)
Family/partner help care for child's teeth	
All the time	144 (34.3)
Most of the time	83 (19.8)
Some of the time	84 (20.0)
Rarely	42 (10.0)
Never	67 (16.0)
Social support, *t*-score, mean (SD) (n = 419)	
Emotional	55.9 (8.9)
Instrumental	54.8 (9.3)
Informational	57.7 (9.8)
Activities of daily life make it difficult to care for child's teeth	
All the time	7 (1.7)
Most of the time	29 (6.9)
Some of the time	84 (20.0)
Rarely	88 (21.0)
Never	212 (50.5)

[a] Values are no. (%), unless otherwise indicated; N = 420 unless otherwise indicated.
[b] The Oral Health Knowledge Scale was developed by the Knowledge and Behavior Workgroup of the Early Childhood Caries Collaborating Centers (31).

Table 2. Factors Associated with Frequency of Child Tooth Brushing Among Children Aged 6 to 36 Months (N = 420), Coordinated Oral Health Promotion Chicago Study, Chicago, Illinois, 2018–2019[a]

Variable	Full Model			LASSO 20% Frequency Selection			LASSO 40% Frequency Selection		
	β	SD	10% CI	Mean β	SD	90% CI	Mean β	SD	90% CI
Intercept	0.423	0.649	−0.644 to 1.489	−0.610[b]	0.253	−1.02 to −0.164	−0.613[b]	0.139	−0.835 to −0.381
Activities of daily life make it difficult to care for child's teeth	−0.127[b]	0.033	−0.182 to −0.072	−0.102[b]	0.035	−0.158 to −0.043	−0.105[b]	0.034	−0.161 to −0.048
Caregiver age in years	0.002	0.006	−0.007 to 0.012	0.003	0.005	−0.005 to 0.012	—	—	—
Caregiver/adults help with brushing	0.282[b]	0.041	0.214 to 0.349	0.273[b]	0.040	0.206 to 0.339	0.292[b]	0.037	0.229 to 0.354
Caregiver frequency of brushing	0.378[b]	0.055	0.287 to 0.468	0.386[b]	0.055	0.294 to 0.474	0.397[b]	0.058	0.299 to 0.490
Child age in months	0.015[b]	0.006	0.006 to 0.025	0.014[b]	0.006	0.005 to 0.023	0.014[b]	0.005	0.006 to 0.022
Correct toothpaste amount	0.098	0.071	−0.019 to 0.214	0.082	0.072	−0.031 to 0.206	0.115[b]	0.068	0.004 to 0.221
Family/partner help care for child's teeth	0.078[b]	0.025	0.037 to 0.118	0.058[b]	0.023	0.019 to 0.096	0.058[b]	0.023	0.021 to 0.096
Fluoride toothpaste used	0.004	0.071	−0.113 to 0.122	0.032	0.068	−0.082 to 0.145	—	—	—
Frequency of sweet or sugary foods	−0.004	0.005	−0.012 to 0.005	−0.005	0.004	−0.012 to 0.003	—	—	—
Household chaos	−0.089	0.064	−0.194 to 0.016	−0.042	0.062	−0.147 to 0.059	—	—	—
Household income in last year, $									
<30,000	0.091	0.081	−0.042 to 0.223	0.107	0.080	−0.026 to 0.238	0.100	0.078	−0.029 to 0.236
30,000–60,000	−0.057	0.093	−0.210 to 0.095	—	—	—	—	—	—
>60,000	−0.144	0.144	−0.381 to 0.093	—	—	—	—	—	—
Unknown/refused	1 [Reference]			—	—	—	—	—	—
Length of time since child's last dental visit	0.065	0.056	−0.028 to 0.158	0.047	0.054	−0.043 to 0.136	—	—	—
Observed brushing time in seconds	0.001[b]	0.001	0.000 to 0.002	0.001[b]	0.001	0.000 to 0.002	0.001[b]	0.001	0.000 to 0.002
Total ECOHIS Score	0.008	0.008	−0.005 to 0.021	0.012[b]	0.007	0.000 to 0.024	—	—	—

Abbreviations: —, not applicable; ECOHIS, Early Childhood Oral Health Impact Scale; LASSO, Least Absolute Shrinkage and Selection Operator.
[a] Models include 32 variables; only significant variables are reported in the table. All models also control for a partner site. The full model uses categorical variables as a single construct, whereas LASSO treats the set of indicator variables from the same categorical variables as independent variables. The coefficients for the household income variable represent differences from the reference category in the full model, but in the LASSO models the coefficients represent differences from all categories not selected into the model.
[b] Significant at $P < .10$.

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Table 3. Factors Associated with Higher Child Plaque Score Among Children Aged 6 to 36 Months (N = 420), Coordinated Oral Health Promotion Chicago Study, Chicago, Illinois, 2018–2019[a]

Factor	Full Model			LASSO 20% Frequency Selection			LASSO 40% Frequency Selection		
	β	SD	10% CI	Mean β	SD	90% CI	Mean β	SD	90% CI
Intercept	1.717[b]	0.628	0.684 to 2.749	1.939[b]	0.204	1.593 to 2.276	2.010[b]	0.107	1.833 to 2.181
Caregiver/adults help with brushing	−0.094[b]	0.040	−0.159 to −0.028	−0.102[b]	0.040	−0.167 to −0.034	−0.092[b]	0.040	−0.156 to −0.028
Caregiver age in years	−0.005	0.005	−0.013 to 0.004	−0.004	0.005	−0.012 to 0.004	—	—	—
Caregiver relationship status									
Single	0.261	0.147	0.019 to 0.503	0.114	0.071	−0.007 to 0.225	—	—	—
Living with partner/spouse	0.134	0.140	−0.096 to 0.365	—	—	—			—
Separated/divorced	1 [Reference]			—	—	—	—	—	—
Child race/ethnicity									
Black	0.066	0.155	−0.189 to 0.322	—	—	—	—	—	—
Hispanic	0.198	0.154	−0.056 to 0.450	0.127[b]	0.073	0.008 to 0.252			—
Other	0.372	0.254	−0.046 to 0.791	0.347[b]	0.181	0.040 to 0.628			—
White	1 [Reference]			—	—	—	—	—	—
Observed brushing time in seconds	−0.001[b]	0.001	−0.002 to −0.000	−0.001[b]	0.001	−0.002 to −0.000	−0.001	0.001	−0.002 to 0.000
Fluoride toothpaste used	0.093	0.069	−0.021 to 0.207	0.109[b]	0.065	0.002 to 0.218	—	—	—
Frequency of sugary beverage consumption	0.014[b]	0.005	0.006 to 0.023	0.014[b]	0.005	0.005 to 0.022	0.014[b]	0.005	0.006 to 0.022
Frequency of sweet/sugary foods	0.008	0.005	−0.000 to 0.016	0.007	0.005	−0.001 to 0.015	0.009[b]	0.005	0.001 to 0.017
Household income in last year, $									
<30,000	0.187[b]	0.078	0.058 to 0.315	0.175[b]	0.074	0.049 to 0.292	0.153[b]	0.071	0.036 to 0.268
30,000–60,000	−0.004	0.090	−0.152 to 0.144	—	—	—	—	—	—
>60,000	0.007	0.139	−0.222 to 0.236	—	—	—	—	—	—
Unknown/refused	1 [Reference]			—	—	—	—	—	—
Total ECOHIS Score	0.007	0.007	−0.005 to 0.019	0.005	0.007	−0.006 to 0.017	—	—	—

Abbreviations: —, not applicable; ECOHIS, Early Childhood Oral Health Impact Scale; LASSO, Least Absolute Shrinkage and Selection Operator.
[a] Models include 32 factors; only significant variables are reported in the table. All models also control for a partner site. The full model uses categorical variables as a single construct, whereas LASSO treats the set of indicator variables from the same categorical variables as independent variables. In this model, for caregiver race/ethnicity, caregiver relationship status, and household income, the coefficients in the full model represent differences from the reference category but in the LASSO models, the coefficients represent differences from all categories not selected into the model.
[b] Significant at $P < .10$.

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ORIGINAL RESEARCH

Does Preventive Care Reduce Severe Pediatric Dental Caries?

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Summary

What is already known on this topic?

Increasing dental provider reimbursements for preventive care visits is an effective policy intervention to increase preventive dental visit use among Medicaid-enrolled children.

What is added by this report?

Increased preventive care dental visits did not translate into significant changes in pediatric dental surgeries after a reimbursement-focused policy intervention.

What are the implications for public health practice?

Interventions to reduce pediatric dental surgery should reflect the social determinants of oral health, including access to regular dental care and household oral health behaviors.

Abstract

Introduction

Tertiary oral health services (caries-related surgery, sedation, and emergency department visits) represent high-cost and ineffective ways to improve a child's oral health. We measured the impact of increased Texas Medicaid reimbursements for preventive dental care on use of tertiary oral health services.

Methods

We used difference-in-differences models to compare the effect of a policy change among children (≤9 y) enrolled in Medicaid in Texas and Florida. Linear regression models estimated 4 outcomes: preventive care dental visit, dental sedation, emergency department use, and surgical event.

Results

Increased preventive care visits led to increased sedation visits (1.7 percentage points, $P < .001$) and decreased emergency department visits (0.3 percentage points, $P < .001$) for children aged 9 years or younger. We saw no significant change in dental surgical rates associated with increased preventive dental care reimbursements.

Conclusion

Increased access to preventive dentistry was not associated with improved long-term oral health of Medicaid-enrolled children. Policies that aim to improve the oral health of children may increase the effectiveness of preventive dentistry by also targeting other social determinants of oral health.

Introduction

Dental caries is the most common childhood chronic disease in the United States and worldwide. It disproportionately affects vulnerable children such as those who are poor, receiving Medicaid, of a racial/ethnic minority group, or residents of an underserved area (1,2). The imbalance in incidence of severe caries reflects disparities in oral health care access and use and other social determinants of oral health. In this context, some children among those at high risk for caries develop such severe disease that they seek care in the emergency department (ED) or require dental surgery under general anesthesia (DGA), both of which are costly and often ineffective interventions (3,4).

Clinical care alone does not address the multifactorial causes of caries. Oral health behaviors, caregiver psychosocial state and parenting style, dietary choices, health literacy, and fluoride exposure are only a few factors that influence a child's oral health (5–10). However, policy interventions to improve access to preventive care have focused on provider reimbursement (11), which may be of limited effectiveness in improving access to preventive care, particularly in states with relatively high reimbursement levels or high numbers of dentists participating in Medicaid programs (12). Additionally, although reimbursement may affect getting children to the dental office, it may not influence services received there and may differentially benefit the oldest children rather than the youngest (13). In response to a 2004 US Supreme Court decision that required Texas's Medicaid program to comply with guidelines on increasing access to dental care providers (14), Texas increased the amount of fees reimbursed for dental preventive care by 52.5% on September 1, 2007.

Although increasing access to preventive dental care is important, preventive care alone does not reduce the likelihood of needing tertiary oral health services (caries-related surgery, sedation, and ED visits) (15). Previous research established that Medicaid reimbursements for preventive dental care substantially increased self-reported preventive dental visits in several states (11). However, increasing Medicaid reimbursements to dental care providers for preventive services has not substantially decreased disparities in pediatric oral health related to age, race/ethnicity, and income (16). Medicaid reimbursements can improve access to and use of preventive dental services for some Medicaid beneficiaries, but how this translates into improved oral health outcomes for the population with the highest disease burden — children who require dental procedures with anesthesia — is unknown. Additionally, the clinical efficacy of increased preventive care dental visits to reduce severe caries in early childhood is questionable, because risk factors (oral health behaviors, cultural oral health beliefs) encompass social determinants of health that operate on individual, community, and environmental levels (17). Our study extends knowledge of the effectiveness of a prevention-aimed policy to improve long-term oral health outcomes. Furthermore, ours is the first study to suggest causality between increased preventive dental care and changes in use of tertiary oral health services.

Methods

We studied children aged 9 years or younger who were enrolled in the Texas and Florida Medicaid programs. Texas children were the treatment group, and Florida children were the control. Florida was selected as the control because its trends in reimbursement for preventive dental care were stable during the study period as a ratio of private insurance to Medicaid rates (11).

The estimated prevalence of DGA in the Medicaid population during our study period was ~0.5% to 1% (18,19). A dental surgical event was the primary outcome of interest. In a sample size calculation, assuming $\alpha = 0.05$, $\beta = 0.05$, and power = 0.95, we estimated the ability to detect a difference of 0.1 between treatment and control states in a sample size of 489,102 (20).

Patient demographics and outcomes were derived from Medicaid enrollment and claims files, which we obtained from the Centers for Medicare and Medicaid Services Research Data Assistance Center. Because of budget constraints, we limited our requests for data files for treatment and control states to the pre-reform (2007) and post-reform years (2011 and 2012). This period was selected to reflect prior work that evaluated the impact of these natural experiments on use of preventive dental care (11) and thus allow for the ability to compare changes in outcomes related to tertiary oral health services. This study was granted approval under expedited review by the University of Illinois at Chicago's institutional review board (#2016–0573).

The validity of our findings was threatened by omitted variable bias. If changes in dental services reflect general trends in use of health care services, omission of these unknown variables would result in incorrectly attributing change to policy interventions (ie, increased reimbursements for preventive dentistry). To address this, we measured the effect of increased reimbursements for preventive dental care on appendectomies as a falsification test. If dental surgeries and appendectomies were associated with increased reimbursement for dental care in similar fashion, we would interpret this to signify confounding factors that influence both dental surgeries and preventive dental care reimbursement levels.

Data management. Outcomes were identified on the basis of American Dental Association Code on Dental Procedures and Nomenclature (CDT) (21) or the American Medical Association Current Procedural Terminology (CPT) codes (22) and *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* (23). Surgical cases were identified by a combination of a general anesthesia claim with either the CDT or CPT coding system and a caries-related procedure claim (24), or a combination of a diagnosis of appendicitis and a CPT for an appendectomy. Procedures under sedation were similarly identified. Caries-related emergency department visits were identified by combining ICD-9 codes for nontraumatic dental conditions.

This observational study used difference-in-differences models to establish causal inference between the intervention (policy change) and outcomes. We assumed that any changes in use of dental general anesthesia would not be immediate and theorized that the largest changes in surgery would overlap with children at risk for early childhood caries, because most dental surgeries among Medicaid enrollees occur in children aged 1 to 5 years (19).

We used a linear regression model to estimate 4 outcomes: receipt of a preventive care dental visit, caries-related dental sedation visits, DGA, and an emergency department dental visit. State fixed effects accounted for time-invariant aspects of each state's environment related to outcomes. To control for the possibility that other changes between 2007 and 2012 in the treatment state (Texas) could confound the effect of the Medicaid reforms on use, we used Medicaid-enrolled children from Florida, where no known policy changes occurred during that same period, as a comparison group. The econometric model used for each outcome was as follows:

$$Y = \beta_0 + \beta_S + \beta_1 Year_{2011/12} + \beta_2 TX * Year_{2011/12} + X + error$$

The vector X includes control variables (age, sex, race/ethnicity). Although the control variables are known to be important correlates to receipt of DGA and emergency department visits, the main variables of interest are the year by state interaction effects. For example, β_2 represents the change in DGA in Texas after the Medicaid policy change took effect. The coefficient vector (β_S) represents state fixed effects, which adjusts for varying outcome rates across states.

Results

A total of 7,748,850 children met study inclusion criteria. Demographic differences between Texas and Florida were primarily based on race/ethnicity, because approximately 60% of Medicaid enrollees in Texas were Latino, compared with approximately 30% Latino in Florida (Table 1). Use of all types of visits, unadjusted, increased in Texas between pre- and postpolicy periods: preventive care visit rates increased about 12 percentage points (24% from baseline); dental surgery rates, 0.2 percentage points (14% from baseline); sedation visits, 1.3 percentage points (40% from baseline); and emergency department visits, 0.09 percentage points (22% from baseline).

Reimbursements for preventive care, sedation, general anesthesia, and other caries-related treatment services increased over the study period in Texas (Table 2). Reimbursements for preventive care and general anesthesia provided by medical anesthesiologists (CPT = 00170) did not increase in Florida over the study period.

To isolate changes in use in the policy intervention, we employed a difference-in-differences study design. We found that use changed significantly for all difference-in-differences outcomes (Table 3) when we controlled for time-invariant aspects of each state's environment that related to outcomes and other possible changes between 2007 and 2012. First, we estimated the effect of the policy on all children aged 0 to 9 years. In the postpolicy period, preventive dental care visits increased 11.4 percentage points ($P < .001$, standard error [SE], 0.0008) from a baseline of 50.5%. The policy-associated increase in preventive care dental visits accounted for 93% of the overall increase in such visits. Dental surgery use increased by 0.01 percentage points (SE, 0.00016) in association with the policy intervention (baseline prevalence of 1.43%), without significance. However, surgery for a medical indication (appendicitis) increased significantly by 0.01 percentage points ($P < .01$; SE, 0.00004). Sedation visits increased by 1.7 percentage points ($P < .001$, SE, 0.0003) from a baseline of 3.2%. Emergency department visits for caries decreased in the postpolicy period by 0.3 percentage points ($P < .001$; SE, 0.0001) from a baseline of 0.41%.

Discussion

We found that increasing provider reimbursements was an effective way to increase access to preventive care dental visits. Although tertiary services were not the intended target of our study, use of those services provides useful outcomes to assess long-term effects of increased preventive care visits. We hypothesized that increased preventive care dental visits would improve oral health to the degree that need for tertiary oral health services would be decreased. Our results partially supported this hypothesis by showing decreased dental emergency department visits. Increased reimbursements for preventive dental care were associated with increased sedation visits. Rather than an outcome for severe disease, sedation visits may indicate a population's access to dental providers who diagnose and treat caries.

Although the overall frequency of emergency department visits increased over time in Texas, our model attributed a decline in these visits to a policy intervention to increase preventive care dental visits. Our findings support the idea that the use of emergency department visits is a sensitive indicator of a population's lack of access to preventive dental care. Our findings provide a counterbalance to prior work on the association between declining reimbursements and increased ED visits for caries (25). Such visits for caries represent transient and ineffective care, because typical ED management is to address symptoms without addressing the disease (26). The relationship between timely access to preventive care and use of hospital services such as EDs has been established as a quality metric for medical conditions. The Agency for Healthcare Research and Quality created Prevention Quality Indicators (PQIs) (27), which measure quality of care for sensitive ambulatory care conditions. The rationale in developing PQIs was that certain conditions, when managed appropriately in the outpatient setting, can prevent severe exacerbations that warrant hospital services. PQIs provide a baseline for assessing the quality of health services at the population level and can be used to identify unmet needs (28). Although increased preventive care resulted in increased procedures to treat caries in our study, the decline in ED visits attributed to prevention quantifies the gap in a previously unmet need.

We were concerned about the potential for omitted variable bias, which would lead us to incorrectly attribute changes in use of dental service to a policy intervention that increased reimbursements for preventive dental care. To address this concern, we employed a difference-in-differences model with appendectomies as an outcome. We assumed that appendectomies were unlikely to be directly influenced by preventive dental care reimbursements. Although both dental and medical surgeries increased in association with increased dental reimbursements, only changes in appendectomies were found to be significant. We interpret the difference in significant change between medical versus dental surgical outcomes to further strengthen the validity of our findings that associate changes in use of dental care with increased reimbursements for preventive dental care. Had both dental and medical surgical outcomes changed in similar fashion, we would have concluded that our findings represented more general trends in health care use. Furthermore, a nonsignificant increase in dental surgeries of 0.01 percentage points with a baseline prevalence of 1.43% does not appear to be clinically meaningful at a population level. We interpret this to signify the limitations of an isolated policy intervention to increase access to preventive dental care on the oral health status of the dental surgery population.

Our study had limitations. First, budget constraints limited our study to only 1 year in our prepolicy period (2007) with a gap in data between the prepolicy and postpolicy period (2011–2012). Second, the ability to detect changes in disease burden was limited by use of the CDT coding system. The CDT coding system is an accurate system to track dental procedures, but it is an inadequate measure for the extent and severity of caries. Third, other possible sources of preventive dental care extend beyond dentists. State programs, such as North Carolina's "Into the Mouths of Babes" (https://publichealth.nc.gov/oralhealth/partners/IMB.htm) have facilitated preventive dental care by nondental providers. However, because we defined preventive dental care as a claim for a service rather than specific to type of provider, our results reflect any preventive dental care, including that of primary care providers, reimbursed by Medicaid. Finally, we were unable to specify the mechanisms between increased provider reimbursements for prevention and use of tertiary oral health services. It has been demonstrated that reimbursement affects use of preventive services by expanding dental provider capacity, either by increasing the total number of participating providers or increasing the volume of patients seen by participating providers (12). We did not have access to data related to provider participation in state Medicaid programs, so we could not test for these relationships. Future work should address whether clinical management and treatment patterns change in response to an influx of Medicaid-enrolled children in a dental care delivery system.

Our findings suggest that a focus on other social determinants of oral health may be particularly influential in young children. The contribution of oral health behaviors, such as regular toothbrushing, restricted sugar intake, and exposure to fluoride may have greater impact than preventive care dental visits in families with young children who require dental surgery, particularly if these families do not seek care until after caries have developed. Future interventions may build on our findings by investigating the impact of multilevel interventions that address access to dental care as well as household oral health behaviors to change a population's oral health status.

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Tables

Table 1. Characteristics of Children Enrolled in Medicaid in Prepolicy (2007) and Postpolicy Periods (2011-2012), Florida and Texas

Characteristic[a]	Control: Florida		Intervention: Texas	
	Prepolicy	Postpolicy	Prepolicy	Postpolicy
Total, no.	591,584	2,146,677	1,032,194	3,978,395
Age, mean, y	3.5	4.0	4.1	4.0
Race/ethnicity[b]				
White	29.8	27.9	18.0	15.7
Black	27.2	28.4	14.9	12.9
Latino	32.8	31.9	64.3	58.6
Missing	9.2	10.5	1.3	11.4
Female	48.1	48.6	48.7	48.8
Preventive care visits	22.5	27.1	50.5	62.8
Dental surgery	0.3	0.5	1.4	1.6
Dental sedation events	1.0	0.9	3.2	4.5
Emergency Department visits	0.4	0.7	0.4	0.5

[a] Values are percentages unless otherwise indicated.
[b] We did not include the following race categories: American Indian or Alaska Native, Asian, and Native Hawaiian or Other Pacific Islander; therefore, race percentages will not total 100%.

Table 2. Reimbursement Rates for Preventive Care, Surgery, Sedation, and Emergency Department Visits Related to Dental Caries, Florida and Texas, 2007, 2011, 2012

Reimbursement Codes	Control State				Policy Intervention State			
	Florida, $			Change Post/ Pre, %	Texas, $			Change Post/ Pre, %
	2007	2011	2012		2007	2011	2012	
Preventive care[a]								
D0120	114.5	107.1	108.0	−6.1	22.8	31.4	31.2	37.3
D0150	89.8	88.0	80.5	−6.2	27.4	37.1	36.7	34.7
General anesthesia								
00170[b]	137.0	125.0	132.0	−6.2	154.0	253.0	254.0	64.6
D9220[a]	56.0	72.0	83.0	38.4	87.0	185.0	186.0	113.2
Sedation[a]								
D9241	50.0	62.9	73.5	36.4	101.9	118.8	120.7	17.5
D99143	61.6	100.1	102.8	64.7	59.5	82.1	148.7	93.9
D9248	40.0	50.0	58.9	36.1	144.6	182.8	182.9	26.5
Dental procedures[a]								
D2140	31.1	38.4	46.0	35.7	42.9	63.1	62.8	46.7
D2930	68.0	84.6	100.7	36.3	105.0	153.1	152.7	45.6
D7140	27.0	33.5	39.9	35.9	46.1	66.3	66.1	43.6

[a] American Dental Association Code on Dental Procedures and Nomenclature (CDT) (2011–2012) codes were used to identify reimbursement rates for services (21).
[b] American Medical Association Current Procedural Terminology (CPT) (2011) (22) codes were used to identify reimbursement rates for services.

Table 3. Effect of Policy on of Outcomes of Dental Care and Nondental Care Among Study Group (N = 7,748,850), Results for Difference-in-Differences Models[a]

Linear Regression Model	Preventive Visits	Dental Surgery	Sedation	Emergency Department	Appendectomy
Prepolicy, Texas	0.22[b] (0.000684)	0.00984[b] (0.000139)	0.0154[b] (0.000217)	0.00109[b] (0.000104)	−0.00001 (0.000039)
Postpolicy, Texas	0.021[b] (0.000569)	0.00201[b] (0.0000870)	−0.00345[b] (0.000145)	0.00352 [b] (0.0000978)	0.0000283 (0.0000316)
DiD	0.114[b] (0.000764)	0.000104 (0.000160)	0.0172[b] (0.000250)	−0.00273[b] (0.000122)	0.000108[c] (0.0000439)
Controls[d]	Yes	Yes	Yes	Yes	Yes
Observations, no.	7,748,850	7,748,850	7,748,850	7,748,850	7,748,850

Abbreviation: DiD, difference-in-differences model.
[a] Values are percentage (robust standard error) unless otherwise indicated. Policy impact estimated by looking at the difference-in-differences in outcomes using adjusted linear regression models. Utilization outcomes in Texas (intervention state) and Florida (control state) were estimated for the prepolicy period (2007). Prepolicy outcomes estimates are displayed only for the intervention state (Prepolicy, Texas). Outcomes were estimated in the postpolicy period, 2011-2012 and are displayed only for Texas (Postpolicy, Texas). The difference between pre-and postpolicy estimates between the intervention and control states are the reported results from the difference-in-differences models.
[b] $P < .001$.
[c] $P < .05$.
[d] Linear regression models included the following variables for controls: age, sex, Temporary Assistance for Needy Families recipient, months of private insurance coverage, State Children's Health Insurance Program eligibility, and race/ethnicity.

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ORIGINAL RESEARCH

Awareness Among US Adults of Dental Sealants for Caries Prevention

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PEER REVIEWED

Summary

What is already known about this topic?

Dental sealants are an effective way to prevent cavities. However, sealants are underused, especially in those children who are at the highest risk for untreated cavities.

What is added by this report?

In 2015, about half of adults knew the purpose of dental sealants. Parents had more knowledge than the overall population. We assessed the differences in knowledge among demographic and socioeconomic groups.

What are the implications for public health practice?

By understanding disparities in sealant knowledge, dental professional and public health organizations can develop targeted oral health promotion and education programs. Reaching low-income and racial/ethnic minority parents and parents with only young children could reduce disparities in sealant knowledge and untreated cavities.

Abstract

Introduction

Dental sealants applied in childhood can help prevent caries, but knowledge of the availability of sealants and their function is not widespread. We assessed knowledge of dental sealants among US adults and adult parents of children younger than 18 and the differences in knowledge among demographic and socioeconomic groups.

Methods

We used data on 3,550 respondents to the 2015 FallStyles B survey of noninstitutionalized US adults aged 18 or older. Authors constructed estimates by using weights provided to reflect the distribution of the US population. Knowledge of dental sealants was assessed by sex, age, race/ethnicity, education, household income, and parental status. Multivariate analysis was conducted by using a main effects logistic regression model.

Results

Overall, 46.3% of adults and 55.1% of parents of children younger than 18 had knowledge of dental sealants. Sealant knowledge was highest among parents, women, respondents aged 45 to 59, and respondents with incomes greater than 200% of the federal poverty level and more than a high school education. Non-Hispanic blacks had less than half the odds of non-Hispanic whites of having knowledge of sealants (adjusted odds ratio [OR] = 0.4), and nonparents had half the odds as parents (OR = 0.5) of knowing. The strongest predictors of parental sealant knowledge were race/ethnicity, sex, and income.

Conclusion

Disparities in sealant knowledge correspond to disparities in sealant prevalence. Increasing knowledge among low-income and racial/ethnic minority parents could reduce disparities in sealant prevalence and untreated caries.

Introduction

Although largely preventable, dental caries is one of the most common chronic diseases among children and adolescents (1). National data from 2011 through 2014 show that approximately 18% of children aged 6 to 11 and 58% of children aged 12 to 19 in the United States had treated or untreated caries in their permanent teeth (2). Disparities in caries prevalence exist across races and ethnicities and family income levels, and prevalence is highest among minority and socio-economically disadvantaged populations (2). If left untreated, dental caries can cause pain, speech problems, and missed time from school (1).

About 90% of caries in permanent teeth occur in the posterior teeth (3). Dental sealants are widely recommended by professional health organizations (4,5) because they prevent about 90% of posterior caries one year after placement and about 50% 5 years after placement (6). Prevalence of sealant use in children aged 6 to

11 rose 12.4 percentage points from 1999–2004 to 2011–2014, from 31.1% to 43.6% (7). Children from low-income households (<185% of the Federal Poverty level [FPL], however, are about 20% less likely to receive a sealant than children from higher income households (7).

Recent attention to health literacy highlights the complex relationship between knowledge and actions that support health (8). A recent analysis of sealant prevalence in children found that among high income parents (≥100% of the federal poverty level), sealant prevalence increased with parental education (a proxy for health literacy) (9). Because oral health literacy is required to make informed health decisions and can affect receipt of services, determining public knowledge of the purpose of sealants is important. No national data characterize knowledge of sealants among all US adults and among parents of children younger than 18. We assessed knowledge of the purpose of sealants and the differences in knowledge among demographic and socioeconomic groups. Information from our study provides a baseline for future studies of sealant knowledge and can be used to identify need for promoting oral health education and increasing oral health literacy.

Methods

Styles is a consumer survey of US adults that is conducted in multiple waves throughout the year. Data for our study were taken from the FallStyles B 2015 survey, which was conducted from September 28 through October 16, 2015 (unpublished raw data from Porter Novelli Public Services *Styles 2015 Survey* via Deanne Weber). The 2015 FallStyles B survey is a follow-up to the SpringStyles survey. FallStyles was obtained from 3 sampling waves of GfK KnowledgePanel (GfK), a probability-based online panel of 55,000 noninstitutionalized adults that is representative of the adult US population (10). The first wave of Styles, SpringStyles, was sent to a random sample of panelists aged 18 or older (n = 11,028). SpringStyles included questions about general media habits, product use, interests, and lifestyle. The second wave, SummerStyles, which included questions on health orientations and practice, was sent to a random sample of respondents to the SpringStyles survey (n = 6,172). FallStyles, the third wave, was released in 2 separate surveys — A and B. FallStyles B, which included our question, "Which of the following best describes the purpose of dental sealants?," was sent to 4,665 respondents who completed the SummerStyles survey and had 3,550 respondents, a response rate of 76.1%. FallStyles data were weighted by sex, age, household income, race/ethnicity, household size, education, census region, metro status (if respondents live in a metropolitan area or not), and prior internet access to create a sample reflective of the US Current Population Survey proportions. We were granted access to the FallStyles B data through a data-use agreement with Porter Novelli Public Services. Our study was exempt from institutional review board review because personal identifiers were not included.

Dental sealant knowledge, our dependent variable, was recorded as present if a respondent selected "to prevent tooth decay" in answer to the multiple choice question, "Which of the following best describes the purpose of dental sealants?" Incorrect responses included "to fill cavities," "to improve appearance of teeth," "to hold dentures in place," "to protect teeth while playing sports," or "I don't know." Independent variables included sex (male, female), age (18–29, 30–44, 45–59, ≥60 y), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), education (<high school diploma, high school diploma, more than a high school diploma), parental status (having a child aged <18 y), having young children (oldest child aged <6 y), and household income relative to the FPL (based on income and household size). Household poverty status was calculated by using self-reported household size and family income and applying the Department of Health and Human Services 2015 US Federal Poverty Guidelines (11). Household income was dichotomized into 2 categories: poor (≤200% of the FPG) and not poor (>200% of the FPG).

We examined the distribution of independent variables for all adults and for parents. Because sealants typically are delivered to children and adolescents under parental authority, all analyses were conducted both for all adults and for parents. We used the χ^2 test of independence to determine if sealant knowledge was associated with our explanatory variables. To explore factors associated with sealant knowledge after controlling for covariates, we performed multivariate analyses by using a main effects logistic regression model. Adjusted odds ratios and 95% confidence intervals were calculated for overall adult and parental knowledge. All reported findings were significant at $P < .05$.

We used SAS version 9.3 (SAS Institute Inc) for all data management, analysis, and modeling. Missing data represented a small percentage of the overall sample: 7 respondents, 2 of whom were parents, did not respond to the sealant question. Because we did not assume that failure to respond meant that a respondent did not know the answer to the question, missing data were excluded.

Results

Of the 3,550 adult respondents to the 2015 FallStyles B survey, 27.5% indicated that they had at least one child younger than 18. Most of both the overall adult and parent samples were non-Hispanic white, were not poor, and had more than a high school education. Approximately half of the adult sample was aged 30 to 59, compared with over 80% of the parent sample (Table 1).

Dental sealant knowledge among all adults was 46.3% (Table 2). In the bivariate analysis, sealant knowledge was associated with all independent variables. More than half of respondents who were parents, who had more than a high school education, or who were women, aged 45 to 59 years, non-Hispanic white, and not poor had sealant knowledge. In the multivariate analysis, all independent variables were significant. Adults who were non-Hispanic black, poor, had not graduated from high school, or were not parents had half the odds of knowing of dental sealants as those who were non-Hispanic white, not poor, had more than a high school education, or were parents.

Approximately 55% of parents had knowledge of dental sealants. Knowledge among parents was consistently higher compared to knowledge among all adults across all subcategories (Table 2). The greatest difference between adult and parental sealant knowledge was among respondents aged 60 or older. In the bivariate analysis, parental sealant knowledge varied significantly among all variables except age. Parental knowledge mirrored that of adults in general: higher among respondents who were women, non-Hispanic white, had higher-incomes, had more than a high school education, or had older children. Parents who were male, members of racial/ethnic minority populations, poor, less educated, or had children aged under 6 all had less knowledge. (Table 3) In the multivariate analysis, sex, race/ethnicity, and income remained significantly associated with parental knowledge.

Discussion

We found that approximately 50% of adults overall and 55% of parents knew the purpose of dental sealants. Results from our study are consistent with previous research that found adult sealant knowledge was higher among women, non-Hispanic whites, parents, and those with more than a high school education and who were not socioeconomically disadvantaged. (12–15). Additional variables found in the literature to be associated with adult knowledge were marital status, past-year dental visit, and being dentate (having teeth) (13–15). We did not include these variables in our analysis because FallStyles did not include questions on use of dental care or dentate status, and parental status was highly correlated with marital status. Consistent with findings from other studies (14,15), our analysis found that parental status was a strong predictor of sealant knowledge, and parental knowledge was associated with sex, race/ethnicity, and income (16,17).

A factor associated with increased parental sealant knowledge not included in our study is children's use of dental care. A survey of Australian parents found that dentists were parents' main source of dental information and that sealant awareness was associated with frequency of dental visits, type of dental center attended, and discussion of caries prevention with a dental professional (18). Similarly, studies have found the presence of sealants to be associated with a recommendation from a dental health care professional, having dental insurance and a regular source of dental care for the child, knowing of or being exposed to information about sealants, and sources of sealant information (19–22).

Studies indicate that children of parents with knowledge of dental sealants are more likely to have dental sealants (19,20). However, these studies did not assess whether knowledge was obtained before or after the child's receipt of sealants, whether knowledge was a driving factor for the parent to seek the intervention, or if knowledge was a result of receiving the intervention. Nonetheless, these studies highlight the importance of sealant knowledge and suggest that discussion of sealants with a dental professional increases parental sealant knowledge and may lead to increased sealant prevalence.

Although knowledge without access to dental care will likely not change behavior, neither will access without knowledge (9). A basic premise of health literacy is that people must know about services to benefit from them. To make an informed decision whether to accept sealants in a clinical setting or to allow a child to participate in a school program, parents must have knowledge of dental sealants. Dental professionals play an important role in educating parents and caregivers about these programs and increasing sealant knowledge. Studies indicate that dentists can successfully persuade patients to accept procedures when the dentist has better knowledge than the patient about the needed procedure. This could explain why when states provide incentives for sealant placement for children covered by Medicaid, an incentive for dentists to increase sealant knowledge, more sealants are placed (23).

The American Academy of Pediatric Dentistry (AAPD) provides guidance on preventive dental services and anticipatory guidance for children (24). For children aged 2 to 6, AAPD recommends that dental health care personnel provide sealants for caries-susceptible primary molars and permanent molars, premolars, and anterior teeth; children should be reassessed at recall appointments to determine the need for new sealants or maintenance of existing sealants. In addition, the American Dental Association supports the use of sealants and encourages dentists to speak to their patients or parents about them (4). For parents of young children, especially those who are poor or from racial/ethnic minorities, initiating these discussions as early as possible could better prepare parents for sealant placement. However, because dental care is reduced among low-income and racial/ethnic minority families and among parents with only very young children, relying on dental professionals to provide sealant information is problematic (25).

School nurses and pediatricians could help increase knowledge of dental sealants. School sealant programs are a successful and cost-effective strategy to increase sealant receipt among children who typically lack access to clinical dental care (7,26). A major barrier to successful implementation of these programs is low consent rates, which might be influenced by parental lack of sealant knowledge. Our finding that parents with only children younger than 6 have less knowledge of sealants is consistent with a recent study in Maryland that conducted a focus group of low-income parents or caregivers of children aged 6 and younger and pregnant women. That study found that very few of the participating parents had heard of dental sealants (27).

Our study had limitations. Styles uses market research databases and is not intended for health surveillance. Survey respondents had already replied to 2 surveys before completing the FallStyles B survey and were more likely to be responders than the average population. Although our data cannot be considered nationally representative, a study comparing Styles to 9 items from the Behavioral Risk Factor Surveillance System found Styles data to be both reliable and valid (28). Styles was only offered in English and does not represent non-English speakers. In addition, compared with similar previous surveys, the 2015 survey included a markedly decreased number of parents of children younger than 18. Because the sample size of parents was small, parental knowledge results should be interpreted with caution. Next steps that might be helpful in developing health promotion and educational efforts at the national, state, or local level include identification of stakeholders and potential collaborators, collection of area-specific data and data among non-English speaking populations (especially non-English–speaking parents), and the identification of methods successfully used to improve knowledge among selected populations. Efforts should be made to standardize questions used to assess health literacy so results across different studies can be compared.

Although prevalence of dental sealants has increased, they are still underutilized among children at risk for untreated caries (7). We found corresponding disparities in knowledge of the preventive purpose of sealants. The dental community remains a major source of information on the preventive benefits of sealants. Further efforts by dental professional organizations and public health organizations to develop oral health promotion and education programs to reach low-income and racial/ethnic minority parents and parents with only young children could reduce disparities in sealant knowledge and untreated dental caries.

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Tables

Table 1. Demographic Characteristics of Respondents (N = 3,550), Awareness Among US Adults of Dental Sealants for Caries Prevention, FallStylesB Survey[a], 2015

Characteristic	All Adults % (SD), N = 3,550	Parents[b], % (SD), N = 716
Sex		
Male	48.7 (65.5)	48.2 (58.9)
Female	51.3 (65.5)	51.8 (58.9)
Age, y		
18–29	21.3 (59.6)	14.3 (45.5)
30–44	25.0 (59.6)	56.0 (58.9)
45–59	26.3 (53.6)	26.2 (48.2)
≥60	27.4 (53.6)	3.6 (21.4)
Race/ethnicity		
Non-Hispanic white	66.3 (65.5)	58.8 (58.9)
Non-Hispanic black	11.3 (41.7)	11.3 (37.5)
Hispanic	14.8 (47.7)	21.2 (50.8)
Other	7.6 (41.7)	8.7 (40.1)
Education		
<High school diploma	11.6 (47.7)	13.6 (50.8)
High school diploma	29.7 (59.6)	21.6 (45.5)
>High school diploma	58.7 (65.5)	64.8 (58.9)
Household income, % of federal poverty level		
≤200	29.8 (59.6)	31.5 (56.2)
>200	70.2 (59.6)	68.5 (56.2)
Parent[b]		
Yes	27.5 (59.6)	—
No	72.5 (59.6)	—
Sealant knowledge		
Yes	46.3 (65.6)	55.1 (58.9)
No	53.7 (65.5)	44.9 (58.9)

Abbreviations: —, not applicable; SD, standard deviation.
[a] FallStyles B, a product of GfK's KnowledgePanel (10) was sent to 4,665 participants and had 3,550 respondents, a response rate of 76.1%.
[b] Of a child aged <18.

Table 2. Knowledge of Dental Sealants Among Respondents (N = 3,550), Awareness Among US Adults of Dental Sealants for Caries Prevention, FallStylesB[a] Survey, 2015

Characteristic	% (SD), N = 3,550	*P* Value	AOR (95% CI), N = 3,550	*P* Value
Overall	46.3 (65.5)	—	—	—
Sex				
Male	42.1 (89.4)	<.001	0.7 (0.6–0.8)	<.001
Female	50.2 (89.4)			1 [Reference]
Age, y				
18–29	40.6 (154.9)	.003	0.7 (0.5–0.9)	<.001
30–44	45.3 (137.0)		0.6 (0.5–0.8)	
45–59	52.0 (113.2)			1 [Reference]
≥60	46.1 (107.2)	003	0.9 (0.7–1.1)	<.001
Race/ethnicity				
Non-Hispanic white	52.1 (71.5)			1 [Reference]
Non-Hispanic black	29.0 (184.7)	<.001	0.4 (0.3–0.5)	<.001
Hispanic	38.8 (178.7)		0.7 (0.6–0.8)	
Other	35.6 (274.1)		0.5 (0.4–0.7)	
Education				
<High school diploma	28.2 (214.5)	<.001	0.5 (0.4–0.6)	<.001
High school diploma	44.0 (113.2)		0.8 (0.7–1.0)	
>High school diploma	51.0 (77.5)			1 [Reference]
Household income, % of federal poverty level				
≤200	31.8 (113.2)	<.001	0.5 (0.4–0.6)	<.001
>200	52.4 (71.5)			1 [Reference]
Parent[b]				
Yes	55.1 (131.1)			1 [Reference]
No	42.9 (71.5)	<.001	0.5 (0.4–0.6)	<.001

Abbreviations: —, not applicable; AOR, adjusted odds ratio; CI, confidence interval; SD, standard deviation.
[a] FallStyles B, a product of GfK's KnowledgePanel (10) was sent to 4,665 participants and had 3,550 respondents, a response rate of 76.1%.
[b] Of a child <18.

Table 3. Knowledge of Dental Sealants among US Parents of a Child Aged <18, Awareness Among US Adults of Dental Sealants for Caries Prevention, FallStylesB[a] Survey, 2015

Characteristic	% (SD, N = 716	*P* Value	AOR (95% CI), N = 716	*P* Value
Overall	55.1 (58.9)	—	—	—
Sex				
Male	48.2 (83.0)	.003	0.5 (0.4–0.7)	<.001
Female	61.6 (83.0)		1 [Reference]	
Age, y				
18–29	42.6 (176.6)	.06	0.6 (0.4–1.2)	.31
30–44	55.0 (77.6)		0.8 (0.6–1.3)	
45–59	60.6 (99.0)		1 [Reference]	
≥60	65.8 (264.9)	.06	1.7 (0.6–4.5)	.31
Race/ethnicity				
Non-Hispanic White	65.0 (66.9)		1 [Reference]	
Non-Hispanic Black	38.7 (179.3)	<.001	0.4 (0.2–0.6)	<.001
Hispanic	44.1 (141.8)		0.5 (0.3–0.7)	
Other	36.7 (232.8)		0.3 (0.2–0.6)	
Education				
<High school diploma	39.7 (200.7)	.04	0.8 (0.5–1.4)	.79
High school diploma	55.2 (120.4)		0.9 (0.6–1.4)	
>High school diploma	58.3 (66.9)		1 [Reference]	
Household income, % federal poverty level				
≤200	44.3 (109.7)	<.001	0.7 (0.5–1.0)	.03
>200	60.0 (66.9)		1 [Reference]	
Age of oldest child, y				
<6	49.2 (93.7)	.02	0.7 (0.5–1.0)	.05
≥6	59.9 (74.9)		1 [Reference]	

Abbreviations: —, not applicable; AOR, adjusted odds ratio; CI, confidence interval; SD, standard deviation.
[a] FallStyles B, a product of GfK's KnowledgePanel (10) was sent to 4,665 participants and had 3,550 respondents, a response rate of 76.1%.

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COMMENTARY

Oral Health and COVID-19: Increasing the Need for Prevention and Access

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PEER REVIEWED

Summary

What is already known on this topic?

Oral health is an important component of health and overall well-being.

What is added by this report?

Nonemergency dental care has been curtailed during the coronavirus disease 2019 (COVID-19) pandemic. Reopening dental practices involves unique challenges and provides opportunities to increase focus on prevention and nonaerosol-generating procedures.

What are the implications for public health practice?

Vulnerable populations are at high risk for COVID-19 and oral and other chronic diseases, and they also have less access to health care services. Removing policy, regulatory, workforce, and reimbursement barriers and incentivizing prevention would increase access to oral health care and improve population health.

Abstract

Populations disproportionately affected by coronavirus disease 2019 (COVID-19) are also at higher risk for oral diseases and experience oral health and oral health care disparities at higher rates. COVID-19 has led to closure and reduced hours of dental practices except for emergency and urgent services, limiting routine care and prevention. Dental care includes aerosol-generating procedures that can increase viral transmission. The pandemic offers an opportunity for the dental profession to shift more toward nonaerosolizing, prevention-centric approaches to care and away from surgical interventions. Regulatory barrier changes to oral health care access during the pandemic could have a favorable impact if sustained into the future.

Introduction

On March 11, 2020, the World Health Organization declared the global spread of coronavirus disease 2019 (COVID-19) a pandemic (1). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a new virus with no vaccine or treatment, and the population currently has no immunity. The virus is primarily transmitted by direct or indirect personal contact through airborne respiratory droplets from an infected person (2).

On March 16, 2020, the American Dental Association (ADA), the nation's largest dental association, recommended that dental practices postpone elective dental procedures until April 6, 2020, and provide emergency-only dental services to help keep patients from burdening hospital emergency departments (3). Because of the rise of infections, this recommendation was updated on April 1, 2020, when the ADA advised offices to remain closed to all but urgent and emergency procedures until April 30 at the earliest. As a result, access to dental care substantially decreased. During the week of March 23, 2020, an ADA Health Policy Institute survey indicated that 76% of dental offices surveyed were closed but seeing emergency patients only, 19% were completely closed, and 5% were open but seeing a lower volume of patients (4).

In addition to the lack of widespread COVID-19 testing, point-of-care testing in dental offices also was not available. Because of the inability to test all patients and the fact that asymptomatic or presymptomatic patients could be infectious, ADA guidance shifted in mid-April 2020 as state and local government policies varied regarding criteria for reopening different types of services, including dental services (5). Questions remain about how soon patients will prioritize and resume nonemergency dental care amid other delayed health care services. The full extent of pandemic-related financial strain and loss of dental insurance is not yet clear and will dramatically affect dental care utilization.

In this commentary, we explain why oral health care should be a public health priority in the response to the pandemic and discuss the aspects of dental care that make it challenging to accomplish this. We will also provide opportunities for improvement, such as focusing more on prevention and nonaerosolizing dental procedures and the means by which to increase access to affordable, more equitable care for vulnerable populations.

Importance of Oral Health

In 2000, the first and only Surgeon General's Report on Oral Health (the second is in progress) made clear that oral health is part of overall health and well-being (6). The mouth is indispensable to eating, speaking, smiling, and quality of life. The most prevalent oral conditions are dental caries and periodontal diseases, and they are largely preventable (7). Dental caries is the most common chronic childhood disease and continues into adulthood. Among US adults, 2011–2014 national data indicate that 32.7% had untreated dental caries (8). Furthermore, according to weighted averages from 2009 through 2014, 42% of adults aged 30 or older had periodontitis (9). Oral disease is unevenly distributed in the population by race and ethnicity (Table 1). The progression of oral disease can cause pain, infection, and sepsis, and treatment is expensive. In addition to primary prevention, in early stages the progression can be reversed or arrested with appropriate oral hygiene, fluoride exposure, dental sealants, changes in diet, and other measures.

Populations With Oral Health and Chronic Disease Disparities: COVID-19 Puts Both at Increased Risk

Populations at higher risk for many chronic diseases are similar to those at higher risk for developing oral diseases. Common risk factors include stress, poor diet, alcohol and tobacco use, substance misuse, behavioral health issues, domestic violence, and poverty. Many of these factors have been heightened during the pandemic. These and other social determinants of health lead to both exacerbation of chronic disease and poor oral health outcomes (13).

Populations vulnerable to COVID-19, including those in low socioeconomic groups, minority groups, older adults, low-literacy individuals, those in rural areas, and the uninsured are also at increased risk for oral disease and associated systemic health problems (14). Minority populations are especially at risk during the COVID-19 pandemic. The Centers for Disease Control and Prevention (CDC) notes that "non-Hispanic blacks, Hispanics, and American Indians and Alaska Natives generally have the poorest oral health of any racial and ethnic groups in the United States," (15) and these same populations have disproportionately higher incidence of COVID-19–related infection and death (16).

Among those hospitalized with COVID-19, diabetes and cardiovascular disease are 2 of the most prevalent underlying comorbidities, according to the CDC (17). Periodontal disease is associated with diabetes and cardiovascular disease, although causality is difficult to ascertain because of confounding evidence, and few randomized trials or longitudinal studies have been conducted on the effects of treatment (18,19).

Researchers note, "The COVID-19 pandemic has alarming implications for individual and collective health and emotional and social functioning" and that "health care providers have an important role in monitoring psychosocial needs and delivering psychosocial support to their patients" (20). Research suggests a strong association between oral health conditions like erosion, caries, and periodontal disease and mood conditions like stress, anxiety, depression, and loneliness (21). There are other potential connections downstream between COVID-19 and oral health. With the COVID-19 pandemic's impact on mental health, pandemic-related increases in oral health risk factors, and anticipated declines in per capita dental visits, increasing integrated practice and referrals between dental providers and behavioral health providers will be prudent. Similarly, increased efforts to more effectively integrate dental programs focused on prevention, screening, and risk assessment within primary care, obstetrics and gynecology, and pediatric offices should be pursued to expand access to oral health services for vulnerable populations (22).

COVID-19 and Oral Health Disparities in Access to Care

Access to oral health care is especially limited for populations at high risk for COVID-19. Patients with symptoms of COVID-19 are advised "to avoid nonemergent dental care" (23). Providers are advised, "if possible, [to] delay dental care until the patient has recovered" (23).

More than 49 million US residents live in areas designated by the Health Resources and Services Administration as Dental Health Professional Shortage Areas (24). This shortage has been compounded by the COVID-19 pandemic, which has resulted in limited preventive dental services in the interest of public health safety. Emergency departments, a less-than-ideal but common treatment destination for those facing oral health care access disparities, have also seen a significant drop in visits for health problems unrelated to COVID-19 (25). School-based oral health programs, such as effective dental sealant programs to prevent dental caries — the only source of preventive oral health care for many children in vulnerable populations — have similarly been suspended because of government-mandated school closures (26). Nationally, children in low-income families and at higher risk of caries are less likely to receive sealants than children in higher-income families, at 39% and 46%, respectively (27).

Access disparities are particularly acute for poor and minority populations. Researchers note that "poor and minority children are substantially less likely to have access to oral health care than their nonpoor and nonminority peers" (14). These populations are also more likely to lack dental insurance. A 2020 report notes, "The oral health care safety net is expected to cover . . . one-third of the US population, notably those who are low-income, uninsured, and/or members of racial/ethnic minority, immigrant, rural, and other underserved groups" (28). Many of these populations, which often rely on Medicaid dental benefits, have seen their access restricted or eliminated by reductions in this vital coverage. In 2020 it was reported that "in response to fiscal challenges, many states have reduced or eliminated Medicaid dental coverage over the past decade, with a concurrent 10% decline in oral health care utilization among low-income adults" (28). Among those in at-risk populations who do have dental benefits under Medicaid, the same report notes there is often "difficulty finding Medicaid-contracted dental providers, because only 20% of dentists nationwide accept Medicaid" (28). We can reasonably anticipate a worsening of these trends as the COVID-19 pandemic takes a large proportion of state budgets.

COVID-19 and Dental Care: Aerosol-Generating Procedures Create Risk

Dental professionals have been practicing increased infection control and taking universal precautions since the 1980s HIV epidemic (29). Nevertheless, oral health professionals are among those occupations at the highest risk for COVID-19, as reported by *The New York Times* (30). Dental care personnel face challenges because of their proximity to infected patients. These patients' mouths are open and unmasked during treatment, significantly increasing the potential for direct and indirect exposure to infectious materials. The Occupational Safety and Health Administration designates the performance of aerosol-generating procedures on known or suspected COVID-19 patients as "very high risk" (31). Shortages of personal protective equipment (PPE) and the use of instruments and equipment that generate aerosols containing oral and respiratory fluids only compound the risk (23). Two of the highest aerosol-creating procedures involve inventions that have been considered major advances in dental practice, because they are faster and less painful for the patient: the high-speed handpiece with its water spray coolant and the ultrasonic scaler used by hygienists to remove hard deposits on teeth (32). These dental procedures have become problematic during the pandemic, providing an opportunity to shift to nonaerosolizing procedures and a greater focus on prevention (23,33).

Going Forward: Opportunities

Focus on prevention and promote nonaerosol-generating dental procedures

Prevention is a cornerstone of public health. The COVID-19 pandemic presents an opportunity for the dental profession to shift from an approach focused on surgical intervention to one emphasizing prevention. Embracing nonsurgical, nonaerosolizing caries prevention and management will be critical in this endeavor. The profession has always supported community water fluoridation, and dental hygienists are considered prevention experts (34,35). However, the dental compensation model is based on providing expensive, restorative procedures that are financially out of reach for many people.

Guidelines have been developed to shift the dental care paradigm to a more preventive focus (36–40). Strategies include reduction in common risk factors such as tobacco and alcohol use, promotion of a healthy diet low in sugars, community water fluoridation, topical fluorides, and promotion of oral health in community settings. These oral health messages and interventions should be integrated into medical sites such as primary care and pediatric offices. Prevention and nonsurgical caries management include many options. Evidence-based materials include dental resin sealants, glass ionomers as sealants or as part of atraumatic restorative treatment performed with hand instruments, silver diamine fluoride, sodium fluoride varnish, and other self-applied and professionally applied topical fluorides (40–42). These materials can be applied without generating aerosols, reducing the risk of viral transmission. These methods present a major opportunity to expand access to preventive and restorative care for vulnerable populations, particularly when combined with policy changes increasing hygienists' scope of practice, sustainable payment reform, and changes in the education of oral health professionals.

Providers and payers together have a responsibility to shift toward preventive care, particularly as COVID-19 threatens to increase disparities in oral health care access for the United States' most vulnerable populations. Before the pandemic, Birch et al noted that a review of provider and payer practices made clear that "further work was required on both the provider and payer side to ensure that evidence-based prevention was both implemented properly but also reimbursed sufficiently" (43). As health care compensation moves toward value-based care and a focus on health outcomes, prevention and maintaining oral health and sound tooth structure will shift reimbursement away from the current expensive model of reimbursement for restoration of tooth structure and function (44). In particular, reimbursement policies, which traditionally have incentivized surgical, high-end restorative procedures like crowns and multisurface fillings, must be revisited to prioritize preventive and nonsurgical, nonaerosolizing treatments and make them more financially sustainable.

Improve communication

Communications concerning patient and provider safety are critical (45). Surveillance and monitoring are needed to confirm whether transmission of COVID-19 occurs in the dental office. According to CDC (27), "There are currently no data available to assess the risk of SARS-CoV-2 transmission during dental practice." The availability of PPE for dental care should be monitored, and the effectiveness of various types of PPE should be determined. Many oral health care providers are anxious about returning to work, and many patients may be hesitant to enter a dental office. Communication and clarity are critical, especially with low-literacy populations. Messaging should include the importance of maintaining good oral health and its role in overall health.

Protect and enhance Medicaid reimbursement

Dental coverage under Medicaid is mandated for children, but state Medicaid programs' approaches to oral health services for adults vary significantly, especially in terms of the comprehensive nature of such services (Figure). Only 19 states have "extensive" Medicaid dental benefits for adults (46). Among US adults aged 19 to 64, only 7.4% have Medicaid dental benefits and, alarmingly, 33.6% have no dental insurance benefits (47). The fiscal solvency of dental safety-net clinics will thus remain critical to serving at-risk populations during and after the pandemic. These sites will be needed more than ever, as delayed and postponed treatment increases need for more extensive and urgent care.

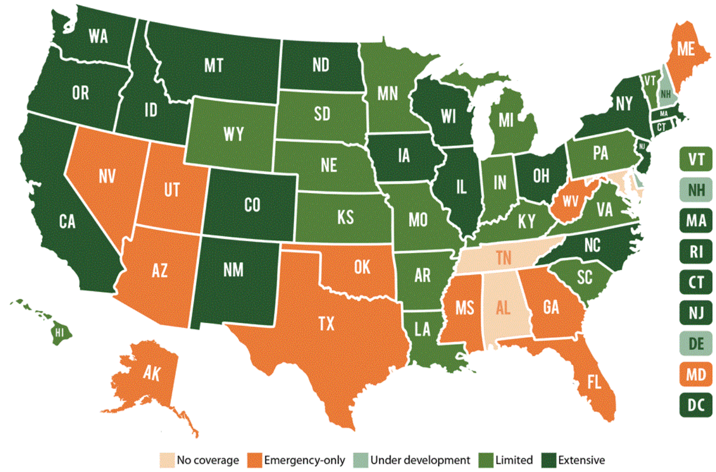

Figure. Extent of Medicaid adult dental benefits, by state. Source: Center for Health Care Strategies (46).

It is widely documented that during economic downturns, Medicaid enrollment increases (48). With unemployment increasing at an unprecedented rate, we can reasonably anticipate the same effect in this pandemic. During times of state budget cuts, dental Medicaid coverage is often at risk (49). In the immediate aftermath of the Great Recession during state fiscal years 2010 through 2012, 19 states reported restrictions in Medicaid adult dental benefits (50). Amidst the pandemic, many states have modified public payment policies to meet the demand of their most vulnerable residents, and it will be important that advocacy efforts secure continuity of these provisional changes. However, given current circumstances, it is imperative that policy makers consider expanding adult dental benefits under Medicaid rather than reducing them. Access disparities will likely increase without expansion of dental benefits under Medicaid.

Ease dental workforce restrictions

Guidance for dental practice during COVID-19 continues to evolve, and regulations vary by state (51). As dental care resumes, it is critical that workforce policies and licensure scope are evaluated to address workforce utilization bottlenecks to respond to communities' needs more effectively and efficiently.

As of 2019, 11 states did not allow for some form of direct access to preventive oral health services by a dental team member outside of the dentist's supervision (52). In these states, a dentist must perform an examination before delivery of preventive care by a hygienist. Easing scope of practice and workforce restrictions would increase access to care. Increasing opportunities for dental team members like dental therapists, community dental health coordinators, and expanded function dental assistants — all currently in limited supply and restricted by dental practice acts in many states — would help bring needed, more affordable services to underserved communities.

Advance teledentistry to address access gaps

The COVID-19 pandemic has thrust alternative modalities such as teledentistry to the forefront of policy considerations (53). Teledentistry supports the delivery of oral health services through electronic communication means, connecting providers and patients without usual time and space constraints. Teledentistry's unique ability to connect disadvantaged, primarily rural communities and the homebound with dental providers (54) makes this method particularly well-suited to address lack of access during and after the pandemic.

Teledentistry can be used for education, consultation, and triage, allowing providers to advise patients whether their dental concerns constitute a need for urgent or emergency care, whether a condition could be temporarily alleviated at home, or whether treatment could be postponed. When many dental offices are closed and people are largely staying at home, communication and information via teledentistry can help lessen the burden of people seeking dental care at overwhelmed emergency departments and urgent dental care settings. In more usual circumstances, teledentistry can also be used to facilitate access to preventive services and oral health education when members of the dental team can provide such services in community settings, such as schools, without onsite dentist supervision.

Before COVID-19, many states inhibited use of teledentistry through legislative barriers and limited public and private insurance reimbursement. Compared with dentistry, many medical and behavioral health providers have less restrictive regulations and insurance reimbursement policies concerning telehealth. A *Washington Post* report (55) was clear: "Telemedicine was largely ready for the influx." Teledentistry, on the other hand, was forced to play catch-up (56). Emergency reimbursement changes prompted by COVID-19 have brought relief, but post-pandemic, we recommend that legislators, regulatory authorities, and third-party payers consider making permanent the temporary modifications to teledentistry policies to support increased access.

Implications for Public Health Practice: Dental Public Health's Roles

Health inequities are avoidable and unjust. Although SARS-Cov-2 has infected people worldwide, it has disproportionately affected those who are most disadvantaged. In the United States, people without good access to health care, healthy food, and a safe environment; with underlying health conditions; who live in crowded conditions; or who have become unemployed and homeless are especially vulnerable and at increased exposure to the virus. It is time to recognize the social determinants of health and rectify unjust conditions, systemic inequality, and racism.

Oral health disparities and inequities are part of the larger, cultural picture. There has been a tendency to blame the victim. Mary Otto, health journalist and author of the groundbreaking book *Teeth* (57), stated, "We see tooth decay through a moral lens, almost. We judge people who have oral disease as moral failures, rather than people who are suffering from a disease" (58).

It is perhaps not hyperbole to describe pandemic-related circumstances as creating a "perfect storm" in oral health care in the United States. Risk factors are elevated, access for the most vulnerable is limited, safety concerns are heightened, and the economy presents substantial challenges for patients and providers alike. The effects of COVID-19 are particularly acute for vulnerable populations, and the crisis has made evident the challenges and opportunities for oral health care in the United States. In such a time, oral health care providers and advocates must clearly communicate the importance of oral health to overall health, indicate the steps being taken to ensure patient and provider safety, and promote prevention and nonaerosolizing procedures (Table 2). Oral health should be included in policy considerations, continued research, monitoring, surveillance, and other aspects of health. Advocacy is crucial to make permanent the temporary regulatory changes being implemented to address the immediate crisis, ensure access to oral health care, address disparities and inequities, and improve population health.

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Tables

Table 1. Percentage of COVID-19 Hospitalized Cases in COVID-NET Catchment Areas and Prevalence of Dental and Other Chronic Conditions in the United States, by Race/Ethnicity, 2020

Characteristic	% of COVID-19 Hospitalized Cases	COVID-NET Catchment Area for Comparison	% of Periodontitis (Gum Disease)	% of Untreated Dental Caries (Tooth Decay)	% With Diabetes (Physician-Diagnosed and Undiagnosed)	% of Self-Reported Heart Disease
Population	COVID-NET, 14 jurisdictions	COVID-NET, 14 jurisdictions	US dentate adults aged ≥30 y	US dentate adults aged 20–64 y	US adults aged ≥20 y	US adults aged ≥18 y
Period	As of June 20, 2020	As of June 20, 2020	2009–2014	2011–2016	2015–2016	2017
Source	CDC (10)	CDC (10)	NCHS, NHANES (9)	NCHS, NHANES (11)	NCHS, NHANES (12)	NCHS, NHIS (12)
Non-Hispanic White	32.8	58.8	37.0	22.2	13.0	11.5
Non-Hispanic Black	32.6	17.7	56.6	40.2	19.6	9.5
Hispanic	22.0	14.0	[a]	[a]	21.5	7.4
Mexican American	[a]	[a]	59.7	37.1	[a]	[a]
Other Hispanic	[a]	[a]	48.5	[a]	[a]	[a]

Abbreviations: CDC, Centers for Disease Control and Prevention; COVID-19, coronavirus disease 2019; COVID-NET, COVID-19–Associated Hospitalization Surveillance Network; NCHS, National Center for Health Statistics; NHANES, National Health and Nutrition Examination Survey; NHIS, National Health Interview Survey.
[a] Studies vary in definitions used for Hispanic ethnicity.

Table 2. Implications of COVID-19 for Oral Health in the United States, 2020

Core Functions of Public Health	Public Health Concerns	Future Opportunities
Assurance	Limited access to dental care compounded by COVID-19; aerosol-generating dental procedures increase risk of transmission	Promote prevention and use of nonaerosol-generating dental procedures; advance teledentistry training and reimbursement and other efforts to reach patients outside of the dental setting
	Regulations in some states limit dental hygienists' and other dental team members' ability to provide care in settings outside of the dental office	Modify state dental practice acts and other regulations for dental workforce reform and to increase access to prevention
	Lack of integration between oral health and the rest of the health care system	Increase integration between oral health care and primary care (ie, locations serving patients who are pregnant, have diabetes or cardiovascular disease)
Assessment	Lack of timely national oral health data and coordinated state and local information	Monitor oral health conditions as a result of delayed dental care during pandemic; include oral health metrics in health care quality measures
	Lack of information about health and safety of dental health care personnel during COVID-19; limited availability of PPE and COVID-19 testing for dental practices	Monitor dental workforce health and safety; increase availability of PPE and COVID-19 tests for dental care settings
	Evidence needed to determine most cost-effective PPE or PPE combinations and other measures to prevent SARS-CoV-2 in dental settings	Further testing of specific PPE and PPE combinations and other measures to protect patient and provider health in dental settings
Policy Development	Potential public and provider unease about seeking and providing dental care during pandemic	Provide clear communication about how to safely obtain and provide dental care during the pandemic
	Oral health not prioritized	Educate about importance of oral health and its relation to the health of the rest of the body; provide parity with health care policies (ie, Medicaid, Medicare)
	Varied state-level adult dental Medicaid benefits	Advocate for sustained dental Medicaid funding and expansion to close coverage gaps
	Reimbursement models incentivize surgical, high-end restorative dental procedures	Modify reimbursement to provide incentives for prevention, maintaining health, teledentistry

Abbreviations: COVID-19, coronavirus disease 2019; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

PCD
PREVENTING CHRONIC DISEASE