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Short Communication

Assessing the relationship between diabetes mellitus and dental caries among US adults: The National Health and Nutrition Examination Survey (NHANES) 2013–2020

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ABSTRACT

Objectives: To assess the relationship between diabetes prevalence and dental caries experience among a representative sample of US adults.
Study design: Cross-sectional study.
Methods: We used data on participants 25 years and older with complete data from the continuous National Health and Nutrition Examination Survey (NHANES) cycles in 2013–2020. We defined diabetes prevalence using glycohemoglobin and self-reported diabetes. Dental caries was operationalized using the decayed, missing, filled teeth (DMFT) score from a standardized dental examination. We used Poisson models to examine adjusted associations with dental caries experience or the DMFT score.
Results: We found a dose-response association between diabetes prevalence and DMFT score (RR = 1.017, 95 % CI: 0.994–1.041 for prediabetes and RR = 1.045, 95 % CI: 1.017–1.074 for diabetes) after adjusting for age, sex, race, education, family income to poverty ratio, smoking status, body weight and last dental visit.
Conclusions: Diabetes prevalence was associated with higher dental caries experience. Future studies should examine the mechanism and interventions to ameliorate this association.

1. Introduction

Dental caries is one of the most common chronic diseases worldwide.[1] In the US, the prevalence of dental caries among adults aged 20–64 was 90% and among adults aged 65 and above was 96% in the period between 2011 and 2016.[2] A number of prior studies have found a positive association between diabetes and dental caries,[3–6] but these have been conducted in small non-representative samples[4,6] or without multivariable regression analysis.[3–6] A study in the US using the National Health and Nutrition Examination Survey (NHANES) from 2015 to 2018 detected higher odds of developing dental caries among diabetic adults;[7] however, this study focused exclusively on self-reported diabetes. There is a lack of representative large studies examining the association between diabetes biomarkers and objectively measured dental caries, so we sought to examine their association.

2. Methods

We used data from the interview, physical examination, and laboratory modules of the National Health and Nutrition Examination Survey (NHANES). NHANES uses a random multi-year, stratified, 4-stage sampling method for participants' recruitment. We utilized data from the 3 NHANES cycles spanning from 2013 to March 2020. These cycles included a total of 35,706 participants; after excluding subjects younger than 25 years (n = 16,623), and individuals with missing data in the variables of interest (n = 4086), our final analytic sample consisted of 14,997 participants (See the participant inclusion/exclusion flow chart in Supplementary Fig. 1). Supplementary Table 1 shows a comparison of individuals with missing data vs complete cases.

The primary exposure variable was diabetes status which was defined using 2 complementary measures: self-reported diabetes and glycohemoglobin (HbA1c) test. We created a 3-category classification:1) Diabetes, 2) Prediabetes and 3) No Diabetes. Diabetes group included participants with a self-report of diagnosis by a physician (answered

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"Yes" to the question about the diagnosis of diabetes) or HbA1c greater than or equal 6.5%; Prediabetes group included subjects not classified as diabetic above, who responded "Borderline" to the question about the diagnosis of diabetes or those with HbA1c between 5.7% and 6.4%; and No Diabetes group included all other subjects.

The primary outcome variable was dental caries experience, calculated using the DMFT (Decayed, Missing due to caries and Filled - Teeth) score. US-licensed dentists working as dental examiners performed oral health examination in the mobile examination centers. Dental examiners gave a specific code for each permanent tooth depending on its condition (see Supplementary Table 2). Via this classification, we computed the individual DMFT score using the overall number of teeth with carious surfaces (Z), with a restored surface condition (F), missing due to dental diseases (E) and missing due to dental diseases but replaced by removable or fixed restorations (P, R). Overall, 28 permanent teeth were assessed for dental caries in each individual. Since the third molars were not evaluated during the dental examination, the DMFT score for our study ranged from 0 to 28. We also created a binary dental caries experience variable using the mean DMFT score (mean = 11) in the study population as a cutoff point.

Based on the literature review, we obtained data on the following confounders: age in years (20–34, 35–49, 50–64 or ≥ 65), sex (male or female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian, or non-Hispanic other), education level (high school or less, some college or more), family income to federal poverty level (FPL) ratio (<100%, 100%–199%, 200%–399% or ≥ 400%), smoking status (never smoker, former smoker or current smoker),[7] obesity (proxied using the body mass index (BMI) and categorized as "Underweight" (BMI < 18.5 kg/m^2), "Normal weight" (18.5 kg/m^2 =< BMI < 25 kg/m^2), "Overweight" (25 kg/m^2 =< BMI < 30 kg/m^2) and "Obese" (BMI ≥ 30 kg/m^2)) and last dental visit ("0–1 years ago", "1–3 years ago", "3–5 years ago", "5 years ago or never").

2.1. Statistical analysis

First, we computed descriptive characteristics of our sample across diabetes categories and overall, describing the outcome variable and other covariates (seen in Supplementary Table 3). Bivariate analysis using Chi-square test and ANOVA was employed to assess the significance of associations between diabetes status and other variables. Second, we used a set of multivariable quasi-poisson regression models to examine the relationship between diabetes prevalence and DMFT score. For this analysis, we fitted a) an unadjusted model, b) a model adjusted for age and gender, c) a model subsequently adjusted for race/ethnicity, poverty level and education, and d) a model subsequently adjusted for smoking, obesity, last dental visit. We also conducted a secondary analysis using dental caries experience (binary DMFT) as the outcome and fitting multivariable Poisson models with robust standard errors. All analyses incorporated the appropriate survey weights to account for the complex multistage sampling design of NHANES. SAS version 9.4 was used for all analyses.

3. Results

Table 1 shows survey-weighted unadjusted and adjusted ratios of the association between diabetes and DMFT score. In unadjusted models (model 0), individuals with diabetes and prediabetes had 42% (95% CI 37%–46%) and 30% (95% CI 27%–34%) higher DMFT score compared to individuals without diabetes. However, these results were attenuated after adjusting for age and sex (model 1, 6% and 3% higher DMFT score in individuals with diabetes and prediabetes, respectively, compared to individuals without diabetes). In the fully adjusted model (model 3), we found a dose-response association between diabetes and dental caries: individuals with diabetes and prediabetes had 4.5% (95% CI 1.7%–7.4%) and 1.7% (95% CI -0.6%–4.1%) higher DMFT scores compared to individuals without diabetes. Supplementary Table 4 shows the results of our secondary analysis using binary DMFT, showing similar results.

4. Discussion

In this analysis examining the association between diabetes and dental caries among US adults from 2013 to 2020, we found that diabetes prevalence is associated with higher dental caries experience. Our findings of higher DMFT scores in individuals with diabetes are consistent with several other studies.[4,6–8] However, these studies either used exclusively a self-reported definition of diabetes[6,7] or conducted exclusively univariate analysis without adjustment for potential confounders.[4,8] In contrast, four other studies using similar exposure and outcome, did not find significantly higher prevalence of caries among individuals with diabetes,[9,10] although these have important design differences or inclusion criteria.

This study contributes to the growing collection of knowledge of the effect of diabetes on dental caries experience. One of the main advantages of our study is using a nationally representative sample which can be generalized to a larger US population. Our measurement of exposure and outcome is another strength, as apart from relying on self-report, we also use laboratory tests for diabetes and rely on dental examination for the DMFT score. Additionally, fitting multivariable regression models to control for confounders helped address gaps existing in many previous studies.

Despite these strengths, we observed several limitations that need to be addressed in future studies. First, the cross-sectional nature of the study creates temporality issues. While we are not explicitly testing causal relationships, we operate under the assumption that diabetes is temporally prior to dental caries, but we cannot assess this in our study, as there is the possibility that poor oral health contributes to worse diet and higher diabetes prevalence. Second, NHANES did not distinguish between type 1 and type 2 diabetes. This could be problematic as type 1 diabetes typically starts at a younger age, thus potentially having longer effect on the development of dental caries. Third, eating habits, particularly excessive and frequent sugar consumption are associated with both type 2 diabetes and dental caries. Our study did not account for nutrition among participants which could cause residual confounding in our analysis. Fourth, the NHANES dental examination did not determine if missing teeth were specifically caused by dental caries, assessing instead whether they were lost due to dental diseases or other causes. The calculated DMFT indices included teeth missing due to dental diseases, potentially encompassing losses from other dental conditions. However, some of these conditions, especially periodontal disease, have also been linked to diabetes. Fifth, although teeth are typically filled or

Table 1
Survey-weighted adjusted and unadjusted relative risk ratios (RR) and 95 % confidence intervals (CI) of the association between Diabetes Status and DMFT score. **N = 14,997.**

	Diabetes	p-value	Prediabetes	p-value	No Diabetes
Model 0: Unadjusted (Crude)	1.416 (1.375–1.458)	<0.0001	1.303 (1.27–1.337)	<0.0001	1 (Ref.)
Model 1: Adjusted for age and gender	1.059 (1.032–1.088)	<0.0001	1.031 (1.007–1.055)	0.0095	1 (Ref.)
Model 2: Model 1 + race, Family income to poverty and education	1.042 (1.014–1.069)	0.0025	1.019 (0.997–1.043)	0.0969	1 (Ref.)
Model 3: Model 2 + smoking status, body weight and last dental visit	1.045 (1.017–1.074)	0.0015	1.017 (0.994–1.041)	0.1483	1 (Ref.)

Results come from a Quasi-Poisson model with DMFT score as the outcome and diabetes prevalence as the exposure, with increasing levels of adjustment by covariates.

restored due to caries, some other non-carious conditions including dental abfraction, attrition, erosion and abrasion can be the reason for fillings as well. Therefore, the number of teeth filled could have overestimated the DMFT score among participants. Lastly, root caries was not assessed in the 2013–2014 NHANES cycle, hence, we did not include root caries in the other cycles (when it was actually measured). Therefore, dental caries for this study only referred to coronal caries which might have underestimated the DMFT score.

Our study contributes to the existing body of evidence related to the relationship between diabetes on dental caries. Despite growing evidence indicating this association, there is still uncertainty around the magnitude and directionality of the association. Future studies should explore potential mechanisms of this association, interventions to ameliorate the impacts of diabetes on oral health, and better measurement of social determinants of health to assess their role in this association.

Ethical approval

Drexel University did not require Institutional Review Board approval, as the project is not considered human subjects research under federal regulations.

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Competing interests

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2024.12.023.

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