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Food insecurity and periodontitis in US adults

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Objectives: To determine the relationship between food insecurity and periodontitis among adults in the United States (US). ***Methods***: Secondary analysis of the 2009-2014 National Health and Nutrition Examination Survey data. The sample included 6,108 US participants aged ≥ 30 years in a probability weighted sample. Periodontitis status was measured in full-month oral examinations at 6 sites per tooth for clinical attachment loss and periodontal probing depth. Food insecurity was assessed by the 18-item US Food Security Survey Module. ***Results***: Controlling for covariates, multiple logistic regression showed that periodontitis was associated with low food security (adjusted odds ratio (aOR)=1.30, 95% CI: 1.08–1.57). Risk factors for periodontitis included HbA1c ≥ 7% (aOR=1.74, 95% CI: 1.26–2.40), seeking emergency dental care (aOR=1.36, 95% CI:1.19–1.55), smoking status, racial minorities, low income, and older age. Protective factors for periodontitis were annual dental visit (aOR=0.52, 95% CI: 0.43–0.64), health insurance (aOR=0.66, 95% CI: 0.54–0.80), female gender, and college education. ***Conclusions***: Food insecurity was associated with a higher risk of periodontitis among US adults. Having enough food to eat is a basic human right and would improve well-being.

Keywords*: periodontal disease, United States, glycemic control, adult, food security, health surveys*

Introduction

Periodontal disease, which encompasses all conditions from gingivitis to advanced periodontitis, results from infections and inflammation of the gums and bone around the teeth. Left untreated, periodontal disease can progress to periodontitis, leading to loss of bone and tooth. Periodontal disease affects close to half of all adults who are 30 years old and older in the United States (US), with 8% of them having periodontitis (Eke *et al*., 2018).

The social and economic determinants of oral health are well documented (Braveman and Gottlieb, 2014). For example, individuals of lower socioeconomic status (Hwang *et al*., 2011), racial minorities (Williams *et al*., 2021), those lacking dental insurance are less likely to have regular dental checkups (Darmawikarta *et al*., 2014). Although the mechanisms are not well understood, recent research points to a link between food insecurity (the inability to access an adequate diet for an active and healthy life) and oral health (Lee *et al*., 2023; Testa *et al*., 2022). There are reasons to expect food insecurity to be related to periodontitis. First, food insecurity is associated with inadequate access to dental care in children, including dental checkups (Anil and Anand, 2017), which may be due to a lack of economic resources needed to access necessary dental services. Second, food insecurity may be an indicator of deprivation, which may not be adequately accounted for in existing studies.

The aim of this study is to determine the relationship between food insecurity and periodontitis. Only one recent study has examined this association and focused on middle-aged and older adults in the US and South Korea, which found an association only for middle-aged adults in the US. However, there are a few limitations from that study that we attempt to improve on. First, we expanded the analysis to all adults older than 30 years and used additional years of data. Second, we included additional covariates to reduce the risk that they confounded this relationship. Given the many negative consequences of periodontitis on health, it is important to have a better understanding of its determinants, especially given that food insecurity affects 12.8% of households in the US (Rabbitt *et al*., 2023).

Method

Data for this study came from the 2009-2014 National Health and Nutrition Examination Survey (NHANES), a publicly available dataset with a cross-sectional, multistage, probability cluster design to produce a sample representing the US civilian noninstitutionalized population (Bahanan *et al*., 2021). Sampling weights were used in regression analyses to account for the complex design (Eke *et al*., 2018).

The study sample includes 6,108 US participants aged ≥ 30 years who received periodontal examinations and completed the food security questionnaire. The dental examination was performed by trained and calibrated dentists in mobile examination centers (MEC) (Eke *et al*., 2018). Participants were listwise excluded if they had incomplete information on one or more variables of interest to this study.

Our main outcome of interest was a binary variable indicating periodontitis. Participants were classified as having periodontitis if their measurement of clinical attachment loss and periodontal pocket depth met the criteria of the case definition set by the Centers for Disease Control and Prevention and the American Academy of

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Periodontology's standard for population-based surveillance of periodontitis (Eke *et al*., 2018). Participants were classified as having periodontitis if they had two or more interproximal sites with clinical attachment loss (CAL) of ≥ 3 mm (on different teeth) and two or more interproximal sites with periodontal probing depth (PPD) of ≥ 4 mm (not on the same tooth) or at least one interproximal site with a PPD of ≥ 5mm. The classification of periodontitis was updated and improved in 2018, with the new guidelines differentiating the staging and grading of periodontitis between severity, complexity, extent, and distribution (Tonetti *et al*., 2018). The updated classification has been shown to outperform the 2012 classification regarding the diagnosis and staging of periodontitis on full-mouth partial recording protocols (Botelho *et al*., 2020). Nevertheless, the 2012 classification used here predicts non-periodontitis patients very well (Botelho *et al*., 2020). Our binary outcome of periodontitis includes both severe and non-severe periodontitis.

Our key independent variable was food insecurity status, measured by the 18-item US Food Security Survey Module (developed by the US Department of Agriculture, USDA) (Rabbitt *et al*., 2023). The survey assessed the participant's conditions and behaviors that characterized difficulty in meeting basic food needs over the preceding 12 months. Households with ≥ 3 affirmative responses (indicating low and very low food security) are considered food insecure.

Confounding factors included glycemic control status, reason for dental care, annual dental visit, age, sex, race/ethnicity, educational level, and income status that were selected based on previous studies (Bahanan *et al*., 2021; Chi *et al*., 2014; Lee *et al*., 2023; Muirhead *et al*., 2009; Testa *et al*., 2022). Laboratory report of HbA1c level was used to measure the participant's glycemic control status (HbA1c < 7% or HbA1c ≥ 7%). Other covariates of health behavior and demographics were self-reported. Participants were classified as dental flossing if they flossed at least once a week. Previous dental visits were dichotomized into two categories (≤ 12 months, > 12 months). We categorized reasons for a dental visit as (1) annual/biannual checkups or prophylaxis and (2) having dental-related pain or needing a dental treatment. Health insurance status was dichotomized as having health coverage in the last 12 months or not. Age (in years) had three categories including young (30-44), middle age (45-64), and elder (65+). The participants' race/ethnicity included 4 groups (non-Hispanic White, non-Hispanic Black, Hispanic, and other race). Educational level had two categories (high school diploma or lower, college or above). Each participant's income level was dichotomized as at below 200% federal poverty level (FPL), or 200% FPL and higher. We also accounted for smoking status and categorized study participants as never smoker, former smoker, and current smoker (Eke *et al*., 2018).

SAS Version 9.4 (SAS Institute, Cary, NC, USA) and R software (version 3.6.3) with the *survey* package (R Foundations) were used for data management and analysis, respectively. The MEC sampling weights were applied to account for the complex design of NHANES that yield estimates generalizable to the US population (Bahanan *et al*., 2021; Eke *et al*., 2018). We used Chi-squared tests to analyze whether the unadjusted prevalence of periodontitis was associated with our explanatory variables. Multiple logistic regression was used to examine the association between food insecurity and periodontitis. Adjusted odds ratios (OR) with 95 percent confidence intervals (95% CIs) were reported, and the significant level of p-values was below 0.05.

Results

The sample included 6,108 participants aged 30 years and older (Table 1). The unadjusted prevalence of periodontitis was 38.7% (95% CI, 35.2 to 42.2). Slightly more than half of the participants were male (51.2%), and more than two-thirds were White (69.9%). About one third (31.3%) had income below 200% of federal poverty level (FPL), and approximately 12.7% were living in families with low food security. Two thirds had a dental visit in the last 12 months, and approximately one third (33.6%) had periodontitis.

Bivariate analysis in Table 1 shows that adults with food insecurity had a higher prevalence of periodontitis (57.1%) than those with food security (36.0%). Periodontitis was higher among participants with uncontrolled glycemia (61.6%) than those with controlled glycemia (37.2%). Participants who did not have a dental visit in the past 12 months had a higher frequency of having periodontitis (31.4% vs 53.2%). Participants who had a dental visit in the past 12 months for only tooth pain or treatment were more frequently to have periodontitis (53.1%) than those whose reasons for a dental visit were oral periodic checkup and teeth cleaning (30.9%). Middle aged and older adults had the highest prevalence of periodontitis (41.9% and 54.4% respectively) compared to younger adults (27.2%). More current smokers had periodontitis (60.3%) than former smokers (42.4%) and never smokers (30.2%).

Multiple logistic regression analysis with adjusted odds ratios in Table 2 shows that participants in food insecure households had 1.30 times greater odds of having periodontitis than those living in food secure households (95% CI, 1.08 - 1.57), after adjusting for age, gender, race, family income, education, dental visits, dental reasons, dental flossing, health insurance, and smoking status. The odds of periodontitis for adults with uncontrolled glycemia were increased by 1.74-fold. Not having dental visits in the last 12 months increased the likelihood of periodontitis by 1.92-fold. Dental visits for only tooth pain or treatment increased the odds of periodontitis by 1.36-fold. Current smokers and former smokers had a higher likelihood of periodontitis (3.08 and 1.43, respectively) compared to never smokers. Racial minorities (Hispanics, African-Americans, and those of other race) had higher odds of periodontitis than Whites. Older adults (middle-aged and elderly) were more likely to have periodontitis than younger adults.

Discussion

The goal of this study was to examine the association between food insecurity and periodontitis among US adults aged 30 years and older using a large national sample. Our main results show that food insecurity is associated with periodontitis. After adjusting for potential

Table 1. Prevalence of periodontitis among adults in the United States.

	n	*Weighted estimate, % (95% CI*	*Periodontitis % (95% CI)*
Overall	6,108	100%	38.7 (35.2 – 42.2)
Age in years (SD)	51.9 ± 14.2	51.1 ± 13.5	
Food security status			
Food security	5,040	87.2 (85.4 - 89.0)	36.0 (32.8 - 39.3)
Food insecurity	1,068	12.7 (10.9 - 14.5)	57.1 (52.7 - 61.6)
Glycemia level			
HbA1c < 7%	5,607	93.6 (92.8 - 94.3)	37.2 (33.7 - 40.6)
HbA1c ≥ 7%	501	6.4 (5.6 - 7.1)	61.6 (54.9 - 68.3)
Annual dental visit			
No	2,406	33.6 (30.9 - 36.1)	53.2 (49.0 - 57.3)
Yes	3,702	66.4 (63.8 - 69.0)	31.4 (28.2 - 34.7)
Reason for dental visit			
Checkup/Cleaning	3,493	64.6 (62.2 - 67.0)	30.9 (27.8 - 34.0)
Hurting/Treatment	2,615	35.3 (32.9 - 37.7)	53.1 (49.4 - 56.8)
Family income level			
≥ 200% FPG	3,417	68.6 (65.0 - 72.2)	31.9 (28.6 - 35.2)
< 200% FPG	2,691	31.3 (27.7 - 34.9)	53.7 (49.4 - 58.1)
Education			
High school or less	2,498	33.4 (30.0 - 36.8)	55.9 (52.5 - 59.3)
College or above	3,610	66.5 (63.2 - 69.9)	30.1 (27.0 - 33.3)
Gender			
Male	2,970	48.8 (47.4 - 50.0)	46.1 (42.4 - 49.8)
Female	3,138	51.2 (49.9 - 52.5)	31.7 (27.9 - 35.5)
Race			
White	2,599	69.9 (65.4 - 74.3)	33.7 (29.7 - 37.6)
Black	1,263	12.7 (9.4 - 15.8)	51.8 (48.0 - 55.6)
Hispanic	1,317	9.9 (7.6 - 12.2)	54.2 (49.2 - 59.2)
Others	929	7.4 (6.2 - 8.6)	43.4 (37.2 - 49.5)
Age groups (in years)			
Young (30-44)	2,213	36.6 (34.1 - 39.0)	27.2 (23.3 - 31.1)
Middle Aged (45-64)	2,608	45.5 (43.3 - 47.8)	41.9 (38.0 - 45.8)
Elder (65+)	1,287	17.8 (16.0 - 19.6)	54.4 (48.9 - 60.0)
Smoking status			
Never smoker	3,446	55.8 (53.9 - 57.7)	30.2 (26.6 - 33.8)
Former smoker	1,534	26.5 (24.6 - 28.3)	42.4 (38.1 - 46.7)
Current smoker	1,128	17.6 (16.3 - 18.9)	60.3 (55.7 - 65.0)
Health insurance			
No	1,278	16.8 (14.9 - 18.7)	55.6 (51.3 - 60.0)
Yes	4,830	83.1 (81.2 - 85.0)	35.3 (31.7 - 38.9)

confounding factors, adults living in food-insecure households were 1.30 times more likely to have periodontitis than those in food secure households.

The findings of our study are consistent with previous studies showing evidence of the negative association of food insecurity on general health, chronic conditions, and self-reported oral health (Bahanan *et al*., 2021; Chi *et al*., 2014; Lee *et al*., 2023; Muirhead *et al*., 2009; Testa *et al*., 2022). A cross-sectional study reported that food insecurity was associated with poor self-reported oral health (prevalence ratio (PR) = 1.12, 95% CI: 1.04 – 1.21) among US adults aged 50 years and older (Chi and Tucker-Seeley, 2013). Food insecurity was also associated with poor self-reported oral health among low-income working-class adults in Canada (Muirhead *et al*., 2009). Food insecure individuals had twice the likelihood of wearing dentures and triple the odds of poor or very poor self-reported oral health than those with food security. They also had higher odds of having dental pain (OR = 1.94) than food-secure participants. Given that the findings are based on a sample of participants in Canada, it is unclear whether they can be generalized to adults in the US. Our study also finds that glycemia level and smoking status are negatively associated with periodontitis, which is consistent with the 2018 guidelines of the American Academy of Periodontology for the grading of disease progression (grades A to C, with C being the highest risk) (Tonetti *et al*., 2018).

Table 2. Multiple logistic regression analysis for predictors of periodontitis among 6108 US adults.

	Adjusted odds ratio (OR)
Food security status	
Food security	Reference
Food insecurity	1.30 (1.08 – 1.57)
Glycemia level	
HbA1c < 7%	Reference
HbA1c ≥ 7%	1.74 (1.26 – 2.40)
Annual dental visit	
No	Reference
Yes	0.52 (0.43 – 0.64)
Reason for a dental visit	
Checkup/Cleaning	Reference
Hurting/Treatment	1.36 (1.19 – 1.55)
Family income level	
≥ 200% FPL	Reference
< 200% FPL	1.31 (1.06 – 1.61)
Education	
High school or less	Reference
College or above	0.56 (0.47 – 0.67)
Sex	
Male	Reference
Female	0.50 (0.44 – 0.57)
Race	
White	Reference
Black	2.26 (1.76 – 2.90)
Hispanic	1.97 (1.58 – 2.45)
Others	1.98 (1.49 – 2.63)
Age groups (in years)	
Young (30-44)	Reference
Middle Aged (45-64)	2.76 (2.20 – 3.47)
Elder (65+)	6.65 (5.12 – 8.64)
Cigarette smoking status	
Never smoker	Reference
Former smoker	1.43 (1.17 – 1.74)
Current smoker	3.08 (2.50 – 3.80)
Health insurance	
No	Reference
Yes	0.66 (0.54 – 0.80)

The findings of our study were in contrast with a recent study using the 2011-2016 NHANES and the 2013-2015 Korea NHANES (Lee *et al*., 2023). The study reported that the association between food insecurity and periodontitis was inconsistent across age group and country. Food insecurity was not significantly associated with periodontitis among older adults in the US and South Korea, but was in middle-aged US adults (OR = 1.60). The significance level of this study was 0.10 instead of 0.05. Whereas we found food insecurity to be associated with periodontitis among US participants aged 30 years and older (OR = 1.30).

There are several possible explanations for our findings. First, it could be that the apparent association we found may be a consequence of residual confounding. While we account for those who have a family income of less than 200% of FPL, it is possible that food insecurity may be an indicator of severe deprivation among the lowest income groups within this income category, which may not be necessarily captured when we lumped them into the less than 200% of FPL category. Second, it could be that individuals living in food-insecure households were more likely to consume a poor-quality diet leading to nutritional deficiencies (Bahanan *et al*., 2021). Previous studies show that food insecurity is negatively associated with diet quality among adults (Chi *et al*., 2014; Lee *et al*., 2023; Muirhead *et al*., 2009; Testa *et al*., 2022). Food insecure households tend to consume less fruits, vegetables, dairy products, vitamin A and B6, calcium, magnesium, and zinc but high amounts of energy dense food compared to those in food secure households. Previous studies showed that poor diet quality may have negative impacts on oral health (Zhu and Hollis, 2014). In addition, food insecure individuals may not have comprehensive dental insurance thus preventing them from being able to access oral preventive care services such as dental prophylaxis (Lee *et al*., 2023). Barriers to dental care may worsen among food insecure older adults since dental benefits are not available for Medicaid beneficiaries in many states and are not covered in traditional Medicare nationally.

The ability to access enough food to live a healthy and active life is considered a basic human right and critical for human health including oral health (Bahanan *et al*., 2021). Maslow's Hierarchy of Need has food (along with water and breathing) as the base of the pyramid of basic human needs required for survival. In 2022, food insecurity affected 12.8% of households in the US including 36.7% of low-income households (Rabbitt *et al*., 2023). The Healthy People 2030 objectives include the goal of reducing the national prevalence of food-insecure households from the 2020 baseline to 6.0% in 2030 (Lee *et al*., 2023).

The present study supports the association between periodontitis and food insecurity. The major strength of this study is that we used clinical measures for several of our key variables of interest (e.g., periodontal disease, glycemia levels), the standard questionnaire from the USDA to assess food insecurity (Food Security Module), and a large US population-based sample. The present study has some limitations. NHANES is a cross-sectional study that does not allow examining a cause-and-effect relationship. Additional longitudinal studies and more recent national US data are needed to better understand the relationship between food security and periodontitis. Another potential limitation relates to the dichotomization of some of our variables, such as income, which may have allowed for residual confounding. While our analysis adjusts for income, it is possible that the association between food insecurity and periodontitis may be explained by deprivation in the poorest quartile or third of our sample.

Efforts to increase oral health for populations need to be carried out on both macro and micro levels (Bahanan *et al*., 2021). At the macro level, policy interventions should promote consuming healthier foods. At the micro level, policies can include (1) providing dental preventive care for individuals with diabetes, (2) adding diabetic screening coverage with annual HbA1c checkup for low-income adults, (3) increasing benefits from nutrition programs (e.g., the Supplemental Nutrition Assistance

Program, (SNAP)), and (4) encouraging local food providers to focus more on producing and advertising affordable nutritious food. Educational programs and public health interventions are needed to help individuals choose healthier food and better control HbA1c that is critical to reduce food insecurity and improve oral health. Future studies should investigate nutritional intake (e.g., sugar intake) using more recent oral health data. In addition, future studies may examine the relationship between food insecurity and periodontitis severity. Lastly, future research should be designed and analyzed within a theoretical model for the etiology of periodontitis with proximal causes and distal determinants. It should use an analytic approach that separates direct and indirect effects and confounding, such as Structural Equation Modelling.

In conclusion, more individuals living in food insecure households had periodontitis than those in food secure households in the US. Our findings support improving the food intake of individuals in food insecure households. Additionally, a more holistic view of health for efforts to improve oral health care is needed to consider the negative association of social determinants of health such as food insecurity. Future studies using prospective data are needed to investigate the underlying mechanisms that may explain the association between food insecurity and periodontitis.

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