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Better diet quality is associated with lower odds of severe periodontitis in US Hispanics/Latinos

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Abstract

Aim—We investigated the cross-sectional association between diet quality and severe periodontitis in a sample of diverse Hispanics from the Hispanic Community Health Study/Study of Latinos.

Materials and Methods—A total of 13,920 Hispanic/Latinos aged 18–74 years of different heritages underwent a full-mouth oral examination and completed two 24hr dietary recalls during 2008–2011. Severe periodontitis was defined as having ≥30% tooth sites with clinical attachment loss ≥ 5mm. Diet quality was assessed using the Alternative Healthy Eating Index (AHEI-2010). We evaluated the association of diet quality with severe periodontitis adjusting for age, sex, nativity status, income, education, last dental visit, current insurance, cigarette smoking, diabetes, and energy intake.

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Results—Relative to those at the lowest quartile of diet quality, individuals at the highest quartile had significantly lower odds of severe periodontitis (adjusted OR=0.57, 95% CI: 0.39–0.82), with evidence of a dose-response relationship across AHEI quartiles. Among AHEI-2010 components, higher consumption of whole grains and fruits, and lower consumption of red/processed meats were associated with lower odds of severe periodontitis.

Conclusion—Better diet quality was associated with lower prevalence of severe periodontitis, though the causal pathways need to be clarified in future work.

Keywords

Diet Quality; Periodontal disease; Periodontitis; Periodontal Inflammation; Hispanics; Latinos

INTRODUCTION

Chronic periodontitis is a group of inflammatory diseases triggered by bacterial insult and characterized by destruction of the tissues supporting teeth (Cekici et al., 2014). Studies have shown that periodontitis is associated with elevated risks of cardiovascular disease (Lockhart et al., 2012, Tonetti et al., 2013) and overall mortality (Garcia et al., 1998). In the US, Hispanics were more likely than non-Hispanic whites to have periodontitis according to the most recent National Health and Nutrition Examination Survey (NHANES, 2009–2012) (Eke et al., 2015). Moderate/severe periodontitis was prevalent in 64% of Hispanics/Latinos over the age of 30 years, many of whom were of predominantly Mexican heritage. However, findings from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) showed vast heterogeneity in the prevalence of moderate/severe periodontitis among Hispanics/Latinos by heritage backgrounds, ranging from 25% among Dominicans to 52% among Cubans (Sanders et al., 2014b). This heterogeneity was not fully explained by conventional risk factors or acculturation indicators, suggesting that there may be other factors contributing to the prevalence of periodontitis in US Hispanics/Latinos. While diabetes mellitus, tobacco smoking, and genetic predisposition are known to influence the manifestation and/or progression of periodontitis (Knight et al., 2016), its pathogenesis is complex and, to date, our understanding of predisposing and protective factors that may contribute to disease experience in Hispanics/Latinos remains incomplete.

Evidence that diet plays a contributory role in the development of periodontitis is emerging. While the extant literature has focused on the influence of individual micronutrients and macronutrients on periodontal health (Najeeb et al., 2016), the mechanisms remain poorly understood. It has been suggested that diets high in refined carbohydrates and saturated fats promote pro-inflammatory cascades involved in periodontitis while diets rich in antioxidants downregulate them (Chapple, 2009). However, few studies have considered the synergistic effects of dietary patterns rather than isolated effects of foods or nutrients on periodontitis.

The alternative healthy eating index (AHEI) was created in 2002 as a measure of diet quality based on foods and nutrients that were shown to be predictive of chronic disease risk. An updated version of the measure was developed in 2010, the AHEI-2010 (Chiuve et al., 2012), which has shown to be useful in predicting risks for chronic obstructive pulmonary

disease (Varraso et al., 2015), cardiovascular disease and type 2 diabetes (Wu et al., 2016). However, the AHEI-2010 has not, to our knowledge, been used to predict oral diseases.

Public health initiatives designed to improve periodontal health through diet modification are both relevant and timely to reduce the burden of chronic inflammatory diseases. Therefore, in the present investigation, we used baseline data from the HCHS/SOL to examine the association of diet quality, as measured by AHEI-2010, with severe periodontitis.

METHODS

Study population

The Hispanic Community Health Study/Study of Latinos is a community based prospective cohort study of 16,415 Hispanic/Latino persons aged 18–74 recruited from randomly selected households using a two-stage probability sampling design (Lavange et al., 2010). The population is drawn from four US field centers (Chicago, IL; Miami, FL, Bronx, NY; San Diego, CA) selected to reflect the diversity and heritage of the Hispanic population in the US—Puerto Rican, Dominican, Mexican, Cuban, Central and South Americans. Baseline measurements were conducted during 2008–2011 and included in-person interviews and a clinical examination. Detailed information regarding the sampling, study design and cohort selection is available elsewhere (Sorlie et al., 2010).

Measures of chronic periodontitis

At the baseline visit, 18 dental examiners, calibrated to study procedures (Sanders et al., 2014b), performed full-mouth periodontal examinations on dentate participants without medical conditions requiring antibiotic prophylaxis. Clinical measurements of periodontitis included: (a) levels of clinical attachment loss (CAL); (b) periodontal probing depths (PD); and (c) bleeding on probing, assessed as the percentage of tooth sites that bled. All measurements were recorded on six sites per tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual), and on all fully erupted permanent teeth excluding third molars.

Measures of PD and BOP assess existing periodontal disease and gingival inflammation, respectively. However, these measures are subject to change with modification of oral hygiene practices and can underestimate past periodontal destruction (Carlos et al., 1987). Since CAL is considered a more reliable measure of lifetime periodontal disease experience (Albandar and Rams, 2002), we defined cases of severe periodontitis as those having ≥30% of tooth sites with CAL ≥5mm in the primary analysis. Secondary analyses used measures of PD and BOP and results are shown in supplementary online material. In sensitivity analyses, we defined cases of periodontitis using measures of CAL at lower severity thresholds such as ≥3 and 4 mm, as well as lower extent thresholds such as 5, 10, and 20% of tooth sites affected. We also used an alternate definition for severe periodontitis recommended by the Centers for Disease Control and Prevention-American Academy for Periodontology (Eke et al., 2012).

Because periodontal disease is a leading cause of tooth loss in adults, (Thornton-Evans et al., 2013) and can potentially reduce abilty to chew certain foods such as fruits and vegetables (Nowjack-Raymer and Sheiham, 2007, Tsakos et al., 2010), we included functional dentition as a stratification variable in the present study. Participants had a functional dentition if ≥9 permanent teeth were present, including dental implants, at the time of the oral examination. Those with <9 teeth were classified as having a non-functional dentition.

Measure of diet quality

Dietary intake information was obtained from two 24-hour dietary recalls. The first dietary recall was conducted during the baseline visit and the second was conducted via telephone from five days to three months after the baseline visit. The recalls were administered in either Spanish or English depending on the participant's preference using the Nutrition Data System for Research (NDS-R) software (version 11) developed by the Nutrition Coordinating Center at the University of Minnesota. As described previously (Siega-Riz et al., 2014), data were collected for 139 nutrients, nutrient ratios, food-group serving counts, and other food components, with 88% of participants completing both dietary recalls and 99% completing at least one.

Scoring for the AHEI-2010 was based on 11 component foods and nutrients ascertained from at least one of the 24-hr dietary recalls. Six components for which higher consumption is recommended include vegetables (without potatoes), whole fruit, whole grains, nuts and legumes, long chain (n-3) fats (docosahexaenoic acid and eicosapentaenoic acid), and polyunsaturated fatty acids (PUFA). Four components for which lower consumption is recommended include sugar-sweetened beverages and fruit juice, red and processed meats, sodium, and trans fats. Lastly, one component for which moderate consumption is recommended is alcohol. For each participant, the AHEI-2010 score represents the sum of their eleven individual components' scores, each with a range from 0 – 10 and a score total range of 0 – 110. Higher AHEI-2010 and component scores represent healthy eating habits. Scores for whole grain, sodium and alcohol were gender-specific (Chiuve et al., 2012). AHEI-2010 overall and component scores were categorized into quartiles for the analyses.

Covariates

At the time of enrollment, standardized questionnaires were administered by bilingual interviewers in English or Spanish according to the participant's preference (Sorlie et al., 2010). Sociodemographic characteristics included Hispanic/Latino heritage background (Mexican, Dominican, Puerto Rican, Cuban, Central and South American, and mixed [other]), age, gender, annual household income (<$10,000, $10–20,000, $20,001–$40,000, $40,001–$75,000, and >$75,000), education (less than high school, high school or equivalent, greater than high school), nativity status/duration in the US (US born, foreign-born <10 years in the US, foreign-born ≥10 years in the US), and current health insurance (none, private, or Medicaid). We ascertained dental care utilization by time since last dental visit (<1 year ago, 1–4 years ago, and >4 years ago). Energy intake was estimated using the National Cancer Institute (NCI)-method with valid recalls only (Tooze et al., 2010). The NCI method accounts for intra-person variability by taking into account multiple 24-hour dietary recalls and covariates. For this analysis, adjustments were made for age, sex,

Hispanic/Latino background, clinical center, weekend (including Friday) vs. weekday sequence (1st recall was conducted in person and the 2nd recall by phone), self-reported intake amount of foods (more, same, or less than usual amount) (Siega-Riz et al., 2014). Recalls with daily energy intake below the gender-specific 1st percentile or above the 99th percentile or unreliable according to the interviewer were excluded from further analysis. We ascertained cigarette smoking use by the questions "*Have you ever smoked at least 100 cigarettes in your entire life?*" and "Do you now smoke daily, some days or not at all?" with participants answering 'Yes' to both questions considered as current smokers, those answering 'Yes' to the first question and 'No' to the second as former smokers, and those who answered 'No' to both as never smokers. For current and former smokers, we further assessed the duration and number of packs smoked per year, to derive pack-years smoked. In analyses, we categorized pack-years into tertiles in the overall population.

All participants underwent a clinical examination at baseline and anthropometric measures were recorded. BMI was calculated as weight in kilograms divided by height in meters squared. Diabetes status was determined by levels of fasting plasma glucose, impaired glucose tolerance 2-hrs after a glucose load, and glycosylated hemoglobin (A1C) per American Diabetes Association Guidelines (Rayburn, 1997) and/or by documented use of medications (Schneiderman et al., 2014). All laboratory assays to determine diabetes status were conducted by the HCHS/SOL Central Laboratory, and all specimens were collected using a standardized protocol for collection, storage and shipping.

Out of the 16,415 participants, 838 (5.1%) were excluded because they were edentulous (no natural teeth), 437 (2.7%) were excluded because they did not have an oral examination, 1,097 (6.7%) had an oral examination but were excluded from the periodontal examination, and 123 (<1%) were excluded because they did not have at least one 24-hr diet recall for assessment of diet quality. The final analytic sample was 13,920.

Statistical Analyses

Descriptive statistics showing distributions of participant characteristics were performed for the overall population and according to severe periodontitis. Chi-square tests were computed to assess significance of unadjusted associations between each characteristic and severe periodontitis. To examine associations of diet quality with severe periodontitis, we estimated odds ratios (ORs) and confidence intervals (95% CI) using logistic regression models adjusted for selected covariates. Specifically, four models were fitted: model 1 adjusts for age and gender; model 2 adjusts for sociodemographic characteristics nativity/duration in US, income, education, last dental visit, current insurance; model 3 adjusts for energy intake and conventional risk factors of periodontitis: smoking and diabetes; and model 4 further adjusts for functional dentition. For categorical covariates with missing data (ranging from <1%–8.3% of the analytic sample), we included a dummy category for the missing values in the analyses. We tested for linear trend in ORs across quartiles of diet quality using an ordinal variable for AHEI-2010 scores. In secondary analyses, we examined associations between each AHEI-2010 component score and severe periodontitis by adjusting for the same covariates as in the main effect models in addition to each of the other component scores. To explore whether the association between AHEI-2010 and severe periodontitis was

modified by Hispanic heritage backgrounds, we tested an interaction term between an ordinal Hispanic heritage background variable with a continuous variable for AHEI-2010 scores. In the interaction model, we reported ORs for a 10-unit higher AHEI-2010 score in stratified analyses by Hispanic heritage background.

To address the complex sampling strategy of HCHS/SOL (Lavange et al., 2010), sampling weights were used to account for the unequal probabilities of selection. These are the product of a 'base weight' (probability of participant and its household being selected from the sampling frame) and three adjustments: 1) multiplicative adjustments for differential non-response at the household- and person-level relative to the sampling frame; 2) trimming adjustment to reduce the variability of the weights as well as the impact of extremely large weights on estimation; and 3) calibration adjustment to reflect the 2010 US Census Population according to age, sex and Hispanic background in the target area (i.e., census blocks from which HCHS/SOL sample was sampled from). All analyses account for cluster sampling and the use of stratification in the sample selection. Data management was performed using SAS version 9.4 (SAS Institute, Cary, NC) and analyses using SUDAAN release 11.0.1 (RTI International, Research Triangle Park, NC). We employed a level of significance of 5%, and all significance tests were two-sided.

RESULTS

Characteristics of study population

Table 1 shows the distribution of participant characteristics for the overall population and according to severity of periodontitis. The study sample was relatively young (average age was 44), predominantly of Mexican origin (40%) and foreign-born (76%). Four percent (n=724) of the overall population had severe periodontitis defined as ≥30% sites with CAL >5mm. Clinically, participants with severe periodontitis had a higher number of permanent teeth, deeper probing pocket depths, higher clinical attachment loss, and more bleeding sites than those without severe periodontitis (all P-values<0.001). They were also more likely to be male, to be ≥ 45 years of age, to have lower income and education, to be foreign-born, to have smoked more during their lifetime, to not have visited a dentist in the past year, and to have diabetes mellitus (all *P*-values<0.0001). Cuban Americans had the highest prevalence of severe periodontitis among the Hispanic/Latino heritage groups.

Association of AHEI-2010 scores with severe periodontitis

As shown in table 2 **model 1**, after adjustment for age and gender, higher AHEI-2010 scores were associated with lower odds of severe periodontitis (OR highest versus [vs.] lowest quartile score=0.40, 95% CI: 0.28–0.58), with evidence of a significant dose response relationship (*P* for trend <0.0001). Adjustment for sociodemographic characteristics in **model 2** did not attenuate the association. However, adjustment for conventional risk factors of periodontitis cigarette smoking and diabetes in **model 3**, as well as energy intake, modestly attenuated the association (OR highest vs. lowest quartile=0.57, 95% CI: 0.39–0.82; *P* for trend=0.02). Additional adjustment for fasting and OGTT glucose levels **in model 4** did not appreciably change the estimates. Because most cases of severe periodontitis in our sample were 35 years or older, we we repeated the analyses excluding

individuals younger than 35 years of age and the results remain nearly identical (not shown). When we stratified by functional dentition status in exploratory analysis, we found no evidence for statistical interaction (supplemental table 1). In sensitivity analyses using the CDC/AAP definition for severe periodontitis or different thresholds of CAL and PD, results did not appreciably change (supplemental table 2). Although not shown, similar associations were found when we adjusted for BMI instead of energy intake or when we used a lower thresholds of disease experience (e.g., CAL of 5, 10 and 20%).

Table 3 depicts stratified analyses by Hispanic heritage background. In the fully adjusted model, we observed that the inverse associations were stronger among those of Central/South American, Cuban and among those with mixed/other backgrounds (ORs per 10-unit higher AHEI-2010 score: 0.65, 95% CI: 0.44 – 0.95; 0.72, 95% CI: 0.51 – 1.02; and 0.28, 95% CI: 0.08 – 0.98, respectively). However, these differences in associations were only marginally significant (*P* for interaction=0.05).

Association of component scores with severe periodontitis

Inter-correlations of the 11 AHEI-2010 components (summary statistics are shown in supplemental table 3) revealed generally modest relationships among scores; all Pearson correlations were lower than 0.48 (supplemental table 4). Table 4 depicts associations of each component with severe periodontitis. In the fully adjusted multivariable model, individuals with the highest consumption of whole fruit and lowest consumption of red/processed meats (i.e., the highest quartile scores for those foods) had significantly lower odds of severe periodontitis than individuals with the lowest quartile scores for the same foods (ORs for highest vs. lowest quartile scores: 0.63, 95% CI: 0.42–0.96; 0.41, 95% CI: 0.23–0.73, *P* for trend=0.0015, respectively). Although estimates did not reach statistical significance, we observed a significant trend towards lower odds of severe periodontitis in relation to higher consumption of whole grains (OR for highest vs. lowest quartile scores=0.80, 95% CI: 0.50, 1.27, *P* for trend = 0.0081). In contrast, we observed a significant trend toward higher odds of severe periodontitis in relation to higher consumption of polyunsaturated fats (OR for highest vs. lowest quartile scores=1.41, 95% CI: 0.96, 2.07, *P* for trend = 0.0277). For nuts and legumes, trans fats, long chain fats, sodium and alcohol scores, no associations with severe periodontitis were observed.

DISCUSSION

In this large population of diverse Hispanic/Latino adults living in the US, we found that higher diet quality was independently associated with lower odds of severe periodontitis. The consistent patterns of associations across different severity and extent thresholds of periodontitis further highlight the strength and robustness of our findings, underscoring the importance of diet in the pathogenesis of periodontitis among Hispanics/Latinos. In addition, these results extend the relevance and utility of the AHEI-2010 as a measure predictive of chronic diseases.

To our knowledge, this is the first large scale epidemiological study to objectively and comprehensively assess the role of diet quality on periodontitis in Hispanics/Latinos. Previous data from the National Health and Nutrition Survey (NHANES III) showed that US

adults who maintained healthy eating habits had lower calculus deposits on teeth (Al-Zahrani et al., 2004), and, combined with other health enhancing behaviors such as maintaining normal weight and engaging in recommended level of exercise, had lower prevalence of periodontal disease (Al-Zahrani et al., 2005). Our data are also consistent with a small cross-sectional study of Jordanian adults, which reported lower average CAL and number of missing teeth among those scoring high on an earlier version of the HEI (Bawadi et al., 2011).

Our results showed an inverse association with higher consumption of whole grains and fruits. This is consistent with a large prospective study of middle-aged male US health professionals, which reported similar associations between consumption of whole, but not refined, grains and periodontitis risk (Merchant et al., 2006). A previous study in NHANES (2009–12) found that consumption of whole grains was similarly inversely associated with severe periodontitis in adults (Nielsen et al., 2016). Whole grains are rich in antioxidants and other health-promoting compounds, which are thought to reduce oxidative stress and inflammation (Slavin, 2003). Moreover, whole foods are known to slow the absorption of carbohydrates, thereby lowering blood glucose and improving glycemic control (Lakschevitz et al., 2011). This might plausibly lower risk of periodontitis given that poor glycemic control is an established risk factor for periodontitis.

Lower consumption of red and processed meats was found to be protective against severe periodontitis. While this is a novel finding, increased red meat consumption has been previously linked with higher circulating levels of C-reactive protein and glucose metabolism markers (Montonen et al., 2013, Ley et al., 2014), suggesting inflammation and poor glycemic control as potential mechanisms contributing to periodontitis. Nevertheless, our findings require confirmation in other populations.

We also observed some evidence to suggest that the associations differed by Hispanic/Latino heritage backgrounds. Amongst Dominicans, for example, the direction of the association was reversed. On average, Dominicans were younger than those of other backgrounds, and had a better periodontal profile (Sanders et al., 2014a).This finding could also reflect differences in cultural practices, values, and behaviors of Hispanics/Latinos by their countries of origin, corresponding to different lifetime exposures to risk factors associated with periodontitis. On the other hand, these differences might also be indicative of the diversity in composition of pathogenic oral flora related to periodontitis across ethnicities (Mason et al., 2013). More studies are necessary to confirm or refute these findings.

We note several important limitations to our findings. First, the cross-sectional design limits our ability to make causal inferences; for instance, it is possible that individuals with severe periodontitis could have limited chewing ability affecting their consumption of certain foods (Tsakos et al., 2010, Nowjack-Raymer and Sheiham, 2007). Previous studies have found a positive association between better diet quality and the number of teeth present (Nowjack-Raymer and Sheiham, 2007, Ervin and Dye, 2009). In the present study, the association of diet quality with severe periodontitis attenuated after control for number of permanent teeth, suggesting that the ability to chew food might explain some of the relationship. We also note that individuals consuming a better-quality diet might be more likely to practice other

healthy behaviors not measured in the present study, such as maintaining good oral hygiene that could impact periodontitis such as maintaining good oral hygiene. Another limitation is the lack of information on oral pathogens, which might change with diet and further modulate the inflammatory response (Dagli et al., 2016). The role of oral pathogens is a target for future study in HCHS/SOL. However, despite these limitations, the large and diverse sample size of HCHS/SOL was an important strength. The latter allows not only examination of the associations of interest within the Hispanic population but also the power to examine the heterogeneity of these associations.

In summary, we report an association between better diet quality with lower odds of severe periodontitis in Hispanics/Latinos of diverse heritage backgrounds. Future work should explore these associations in greater depth with longitudinal data to better elucidate any causal pathways.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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CLINICAL RELEVANCE

Scientific Rationale for Study

The relationship between diet and periodontitis is unclear.

Principal Findings

In a large cohort of diverse Hispanics, our findings showed that individuals who ate a better quality diet, particularly those who consumed a higher amount of whole grains and fruits and a lower amount of red/processed meats, were less likely to have severe periodontitis.

Practical Implications

Clinicians are encouraged to promote a high quality diet as part of preventative approaches for risks of periodontitis

Table 1

Distribution of participants overall and according to severity of periodontitis

Characteristics	Unweighted N (weighted %)			
	Overall	<30% sites with CAL ≥5mm	≥30% sites with CAL ≥5mm	P-value*
Total N **	13,920	13,196 (96%)	724 (4%)	
Age in years				<0.0001
18–24	1546 (18.3%)	1546 (18.3%)	0	
25–34	1904 (23.1%)	1897 (24.1%)	7 (1.4%)	
35–44	2625 (21.9%)	2573 (22.3%)	52 (12.4%)	
45–54	4217 (18.7%)	3982 (18.3%)	235 (28.4%)	
55–64	2713 (11.3%)	2417 (10.3%)	296 (32.6%)	
65–74	915 (6.7%)	781 (5.9%)	134 (25.3%)	
Gender				<0.0001
Women	8306 (52%)	7996 (52.7%)	310 (35%)	
Men	5614 (48%)	5200 (47.3%)	414 (65%)	
Hispanic background				<0.0001
Dominican	1220 (10%)	1181 (10%)	39 (5%)	
Central American	1504 (7.5%)	1416 (7.5%)	88 (6.9%)	
Cuban	1861 (18.9%)	1623 (17.5%)	238 (49.3%)	
Mexican	5885 (40.1%)	5688 (40.9%)	197 (21%)	
Puerto Rican	2065 (14.6%)	1955 (14.7%)	110 (12%)	
South American	933 (5%)	888 (5%)	45 (5%)	
Mixed/Other	424 (4.1%)	418 (4.3%)	6 (<1%)	
Nativity/duration in US				<0.0001
US-born	2440 (23.1%)	2402 (23.9%)	38 (4.7%)	
Foreign-born (≥10 y in US)	8058 (47.9%)	7553 (47.2%)	505 (64%)	
Foreign-born (<10 y in US)	3311 (28.1%)	3134 (27.9%)	177 (30.8%)	
Annual family income				<0.0001
<$10,000	1810 (12%)	1672 (11.6%)	138 (20.2%)	
$10,000 – $20,000	4133 (28.6%)	3877 (28.4%)	256 (33.1%)	
$20,001 – $40,000	4457 (31.1%)	4264 (31.5%)	193 (23.4%)	
$40,001 – $75,000	1795 (13.8%)	1756 (14%)	39 (8.3%)	
>$75,000	573 (6.7%)	556 (5.8%)	17 (3.2%)	
Education				<0.0001
< HS	5083 (30.9%)	4716 (30.3%)	367 (44.6%)	
HS or equivalent	3625 (28.7%)	3462 (29%)	163 (22.7%)	
>HS	5182 (40.3%)	4989 (40.6%)	193 (32.6%)	
Current insurance				0.3638
None	7072 (50.8%)	6679 (50.8%)	393 (50.7%)	
Medicaid	2443 (19.3%)	2313 (29.2%)	130 (22.5%)	
Other	4288 (28.9%)	4090 (29%)	198 (26.1%)	

Characteristics	Unweighted N (weighted %)			
	Overall	<30% sites with CAL ≥5mm	≥30% sites with CAL ≥5mm	P-value*
Last dental visit				<0.0001
Less than one year ago	7062 (49.6%)	6774 (50%)	288 (39.9%)	
One to less than four years ago	4789 (34.8%)	4531 (34.9%)	258 (32.5%)	
Four or more years ago	2041 (15.3%)	1863 (14.8%)	178 (27.6%)	
Smoking status				<0.0001
Never	8686 (62.9%)	8396 (64.1%)	290 (35.9%)	
Former				
<4 pack-yr	1062 (6.8%)	1020 (6.8%)	42 (6%)	
4–16.4 pack-yr	833 (5.3%)	786 (5.2%)	47 (7%)	
>16.4 pack-yr	601 (3.4%)	508 (3%)	93 (12.6%)	
Current				
<8.8 pack-yr	1338 (12.4%)	1284 (12.7%)	54 (6.1%)	
8.8–24.75 pack-yr	644 (4.2%)	572 (3.9%)	72 (11.4%)	
≥ 24.75 pack-yr	448 (3%)	333 (2.3%)	115 (18.7%)	
Diabetes				<0.0001
Normal	6045 (51.3%)	5883 (52.5%)	162 (24.4%)	
Impaired glucose tolerance	5395 (35.5%)	5082 (35.2%)	313 (44.3%)	
Diabetes				
Controlled (HbA1c<7%)	1312 (6.9%)	1207 (6.6%)	105 (13.5%)	
Uncontrolled (HbA1c ≥7%)	1148 (6.2%)	1007 (5.7%)	141 (17.5%)	
Obesity				0.1488
Underweight (BMI <18.5)	109 (1.2%)	102 (1.2%)	7 (1%)	
Normal weight (BMI=18.5–<25)	2740 (22.3%)	2607 (22.4%)	133 (18.3%)	
Overweight (BMI=25–<30)	5254 (37.4%)	4963 (37.3%)	291 (40.5%)	
Obese (BMI=30+)	5789 (39.2%)	5500 (39.1%)	289 (40.3%)	
Number of permanent teeth, median (IQR)	25.8 (22.6–27.3)	25.9 (23.1–27.3)	15.1 (7.15–21.5)	<0.0001
PD in mm, median (IQR)	2.11 (1.74–2.47)	2.08 (1.72–2.44)	2.98 (2.54–3.41)	<0.0001
CAL in mm, median (IQR)	0.40 (0.12–1.00)	0.37 (0.11–0.89)	4.36 (3.56–5.33)	<0.0001
% sites with BOP, median (IQR)	36.5 (13.1–74.5)	36.1 (12.9–73.9)	47.7 (20.8–85)	0.0002
AHEI-2010 scores, median (IQR)	47.0 (42.2–52.3)	46.9 (42.1–52.5)	47.6 (43.6–53.5)	0.001

*P-values for Wilcoxon rank sum test for continuous variables and for Pearson chi-squared test for categorical variables

**Categories may not add to the total N due to missing data

Table 2

Association of AHEI-2010 scores with severe periodontitis

AHEI scores (quartiles)	ORs (95% CI) for severe periodontitis					
	non-cases	cases	Model 1*	Model 2**	Model 3***	Model 4†
Lowest quartile‡	3323	156	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Second quartile	3280	200	0.80 (0.61, 1.06)	0.72 (0.55, 0.95)	0.81 (0.59, 1.10)	0.82 (0.59, 1.15)
Third quartile	3307	174	0.55 (0.40, 0.75)	0.55 (0.40, 0.74)	0.74 (0.54, 1.02)	0.74 (0.51, 1.07)
Highest quartile‡	3286	194	0.40 (0.28, 0.58)	0.39 (0.28, 0.56)	0.57 (0.39, 0.82)	0.46 (0.30, 0.72)
P for trend			<0.0001	<0.0001	0.0204	0.006

* Model 1 adjusted for continuous age and gender

** Model 2 further adjusted for nativity/duration in US, income, education, last dental visit, current insurance status

*** Model 3 further adjusted for cigarette smoking, diabetes, predicted energy intake

† Model 4 further adjusted for fasting glucose and 2-hour oral glucose tolerance test (OGTT) levels. Only 13,809 had information on fasting glucose and 11,608 on 2-hour OGTT levels

‡ Lowest quartile corresponds to least healthy diet; highest quartile corresponds to healthiest diet. Cut-points for lowest quartile: AHEI=0 – 43.50; second quartile: AHEI=43.51 – 48.80; third quartile: AHEI=48.81 – 54.40; highest quartile: AHEI=54.41 – 110.0

Table 3

Associations of AHEI-2010 scores with severe periodontitis by Hispanic heritage backgrounds

Hispanic background	Non-cases	Cases	ORs* (95% CI) for severe periodontitis
Total N	13169	723	
Dominican	1181	39	1.39 (0.84 – 2.32)
Central/South American	2304	133	0.65 (0.44 – 0.95)
Cuban	1623	238	0.72 (0.51 – 1.02)
Mexican	5688	197	1.03 (0.67 – 1.58)
Puerto Rican	1955	110	0.97 (0.48 – 1.96)
Mixed/other	418	6	0.28 (0.08 – 0.98)
P for interaction**			0.0505

*ORs per 10-unit higher AHEI-2010 score, and are adjusted for continuous age, gender, nativity/duration in US, income, education, last dental visit, current insurance, cigarette smoking, diabetes, predicted energy intake, and study site

**P-value for interaction (AHEI-2010 scores*Background) where AHEI-2010 scores is entered as a continuous variable in the interaction model

Table 4

Association of AHEI-2010 components with severe periodontitis

AHEI-2010 Components (quartiles)*	Non-cases	Cases	ORs (95% CI) for severe periodontitis	
			Model 1**	Model 2***
Whole grain score				
Lowest quartile†	3218	261	1.00 (referent)	1.00 (referent)
Second quartile	3278	203	0.63 (0.47, 0.83)	0.93 (0.67, 1.29)
Third quartile	3366	114	0.33 (0.24, 0.45)	0.52 (0.35, 0.77)
Highest quartile†	3334	146	0.54 (0.38, 0.77)	0.80 (0.50, 1.27)
P for trend			<0.0001	0.0081
Whole fruit score				
Lowest quartile‡	3303	176	1.00 (referent)	1.00 (referent)
Second quartile	3274	207	0.75 (0.56, 1.00)	0.94 (0.70, 1.28)
Third quartile	3289	191	0.61 (0.45, 0.83)	0.89 (0.64, 1.25)
Highest quartile‡	3330	150	0.35 (0.25, 0.49)	0.63 (0.42, 0.96)
P for trend			<0.0001	0.1468
Vegetable score				
Lowest quartile‡	3342	137	1.00 (referent)	1.00 (referent)
Second quartile	3305	176	1.57 (1.15, 2.16)	1.43 (1.00, 2.03)
Third quartile	3280	201	1.82 (1.30, 2.54)	1.61 (1.06, 2.44)
Highest quartile‡	3269	210	1.64 (1.22, 2.21)	1.38 (0.95, 2.01)
P for trend			<0.0001	0.1361
Nuts and legume score				
Lowest quartile‡	3396	82	1.00 (referent)	1.00 (referent)
Second quartile	3336	147	1.78 (1.19, 2.66)	1.40 (0.93, 2.13)
Third quartile	3273	207	2.00 (1.35, 2.95)	1.39 (0.89, 2.16)
Highest quartile‡	3191	288	2.73 (1.83, 4.07)	1.53 (0.95, 2.46)
P for trend			<0.0001	0.3142
Trans fat score				
Lowest quartile‡	3373	106	1.00 (referent)	1.00 (referent)
Second quartile	3339	142	1.01 (0.67, 1.52)	0.85 (0.58, 1.25)
Third quartile	3305	176	1.15 (0.77, 1.72)	0.84 (0.57, 1.23)
Highest quartile‡	3179	300	1.83 (1.23, 2.72)	1.21 (0.81, 1.82)
P for trend			0.0002	0.0773
Sugar-sweetened beverage score				
Lowest quartile‡	9382	494	1.00 (referent)	1.00 (referent)

AHEI-2010 Components (quartiles)*	Non-cases	Cases	ORs (95% CI) for severe periodontitis	
			Model 1**	Model 2***
Second quartile	867	52	0.77 (0.50, 1.18)	0.81 (0.53, 1.23)
Third quartile	770	62	0.96 (0.62, 1.48)	0.95 (0.62, 1.45)
Highest quartile‡	2177	116	0.55 (0.38, 0.81)	0.70 (0.47, 1.03)
P for trend			0.017	0.312
Red and processed meat score				
Lowest quartile‡	3246	233	1.00 (referent)	1.00 (referent)
Second quartile	3279	202	0.68 (0.50, 0.91)	0.99 (0.71, 1.38)
Third quartile	3316	164	0.37 (0.27, 0.52)	0.69 (0.46, 1.04)
Highest quartile‡	3355	125	0.18 (0.11, 0.29)	0.41 (0.23, 0.73)
P for trend			<0.0001	0.0015
Polyunsaturated fat score				
Lowest quartile‡	3287	193	1.00 (referent)	1.00 (referent)
Second quartile	3306	174	1.18 (0.86, 1.60)	0.95 (0.68, 1.33)
Third quartile	3282	198	2.00 (1.45, 2.77)	1.43 (1.00, 2.06)
Highest quartile‡	3321	159	2.51 (1.79, 3.53)	1.41 (0.96, 2.07)
P for trend			<0.0001	0.0277
Long chain fat score				
Lowest quartile‡	3313	166	1.00 (referent)	1.00 (referent)
Second quartile	3307	174	0.95 (0.70, 1.29)	0.99 (0.69, 1.42)
Third quartile	3285	195	1.02 (0.74, 1.40)	1.24 (0.89, 1.73)
Highest quartile‡	3291	189	0.73 (0.51, 1.04)	1.11 (0.75, 1.64)
P for trend			0.1962	0.5269
Sodium score				
Lowest quartile‡	3288	191	1.00 (referent)	1.00 (referent)
Second quartile	3309	171	0.68 (0.49, 0.93)	1.13 (0.79, 1.62)
Third quartile	3316	165	0.56 (0.41, 0.76)	1.38 (0.91, 2.10)
Highest quartile‡	3283	197	0.34 (0.25, 0.47)	1.13 (0.69, 1.85)
P for trend			<0.0001	0.3559
Alcohol score				
Lowest quartile‡	3315	156	1.00 (referent)	1.00 (referent)
Second quartile	3337	152	0.92 (0.65,1.29)	1.00 (0.71, 1.41)
Third quartile	3237	242	1.12 (0.76, 1.65)	0.88 (0.61, 1.28)
Highest quartile‡	3307	174	0.87 (0.57, 1.34)	0.87 (0.55, 1.36)
P for trend			0.3322	0.8814

* Cut-points for quartiles were: (1) Whole grain scores: lowest quartile AHEI=0 – 1.10, second quartile: AHEI=1.11 – 2.70, third quartile: AHEI=2.71–5.0, highest quartile: AHEI=5.01–10.0; (2) Whole fruit scores: lowest quartile AHEI=0 – 1.50, second quartile: AHEI=1.51 – 2.40,

third quartile: AHEI=2.41 – 3.80, highest quartile: AHEI=3.81 – 10.0; (3) Vegetable scores: lowest quartile AHEI=0 – 3.00, second quartile: AHEI=3.01 – 3.90; third quartile: AHEI=3.91 – 4.80, highest quartile: AHEI=4.81 – 10.0; (4) Nuts and legume scores: lowest quartile AHEI=0 – 4.10, second quartile: AHEI=4.11 – 5.80; third quartile; AHEI=5.81 – 8.10; highest quartile: AHEI=8.21 – 10.0; (5) Trans-fat scores: lowest quartile AHEI=0 – 7.60, second quartile: AHEI=7.61 – 8.10; third quartile; AHEI=8.11 – 8.50; highest quartile: AHEI=8.51 – 10.0; (6) Sugar sweetened beverage scores: lowest quartile AHEI=0, second quartile: AHEI=0.01 – 1.50; third quartile; AHEI=1.51 – 3.00; highest quartile: AHEI=3.01 – 10.0; (7) Red and processed meat scores: lowest quartile AHEI=0–1.90, second quartile: AHEI=1.91 – 3.90; third quartile; AHEI=3.91 – 5.40; highest quartile: AHEI=5.41 – 10.0; (8) Polyunsaturated fat scores: lowest quartile AHEI=0–5.10, second quartile: AHEI=5.11 – 5.70, third quartile: AHEI=5.71 – 6.40, highest quartile: AHEI=6.41 – 10.0; (9) Long chain fat scores: lowest quartile AHEI=0 – 2.40, second quartile: AHEI=2.41 – 3.10; third quartile; AHEI=3.11 – 4.0, highest quartile: AHEI=4.01 – 10.0; (10) Sodium scores: lowest quartile AHEI=0 – 4.50, second quartile: AHEI=4.51 – 6.40, third quartile: AHEI=6.41 – 8.0, highest quartile: AHEI=8.01 – 10.0; (10) Alcohol scores: lowest quartile AHEI=0 – 3.40, second quartile: AHEI=3.41 – 4.0; third quartile: AHEI=4.01 – 5.90, highest quartile: AHEI=5.91 – 10.0

*Model 1 adjusted for continuous age and gender

**Model 2 further adjusted for nativity/duration in US, income, education, last dental visit, current insurance status, cigarette smoking, diabetes, predicted energy intake, and other AHEI-2010 components

†Lowest quartile corresponds to least healthy diet; highest quartile corresponds to healthiest diet