Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

HHS Public Access

Author manuscript

J Clin Periodontol. Author manuscript; available in PMC 2023 April 01.

Published in final edited form as:

J Clin Periodontol. 2022 April ; 49(4): 313–321. doi:10.1111/jcpe.13599.

Periodontal disease and incident prediabetes and diabetes: the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

Nadia Laniado, DDS, MPH, MSc,
Albert Einstein College of Medicine, Jacobi Medical Center Department of Dentistry, 1400 Pelham Parkway South, Bronx, New York 10461

Tasneem Khambaty, PhD,
University of Maryland, Baltimore MD

Simin Hua, MHSc,
Albert Einstein College of Medicine, Bronx NY

Robert Kaplan, PhD,
Albert Einstein College of Medicine, Bronx NY

Maria M. Llabre, PhD,
University of Miami, Miami Fl

Neil Schneiderman, PhD,
University of Miami, Miami FL

Richard H. Singer, DMD, MS, PhD,
Nova Southeastern University, Ft. Lauderdale FL

Qibin Qi, PhD,
Albert Einstein College of Medicine, Bronx NY

Jianwen Cai, PhD,
University of North Carolina at Chapel Hill, Chapel Hill NC

Tracy L. Finlayson, PhD,
San Diego State University, San Diego CA

Adam M. Whalen, MPH,
Albert Einstein College of Medicine, Bronx NY

Carmen R. Isasi, MD, PhD
Albert Einstein College of Medicine, Bronx NY

Corresponding author: Nadia Laniado, DDS, MPH, MSc, Albert Einstein College of Medicine, Jacobi Medical Center Department of Dentistry, 1400 Pelham Parkway South, Bronx, New York 10461, Tel. 718-918-3667 Fax. 718-918-6147, nadia.laniado@einsteinmed.org.

AUTHOR CONTRIBUTIONS:

N. Laniado conceptualized and designed the study, analysed and interpreted the data and drafted the article. T. Khambaty, S. Hua, R. Kaplan, M. Llabre, N. Schneiderman, R. Singer, Q. Qi, J. Cai, T. Finlayson, A. Whalen, and C. Isasi assisted with analysis, interpretation, review and editing of the manuscript. S. Hua and A. Whalen assisted with data management and review of the manuscript. All authors contributed to drafting and revising content and participated in final approval of the article.

CONFLICT-OF-INTEREST STATEMENT

The authors declare that there are no conflicts of interest in connection with this article.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Abstract

Aims—To examine whether baseline periodontal disease is independently associated with incident prediabetes and incident diabetes in Hispanics/Latinos in the United States.

Materials and Methods—This study examined 7,827 individuals, 18-74 years of age without diabetes, from the Hispanic Community Health Study/Study of Latinos. Participants received a full mouth periodontal examination at baseline (2008-2011) and disease was classified using the Centers for Disease Control and Prevention/American Academy of Periodontology (CDC/AAP) case definitions. At Visit 2 (2014-2017) incident prediabetes and diabetes were assessed using multiple standard procedures including blood tests. Multivariable survey Poisson regressions estimated the rate ratio and 95% confidence intervals of incident prediabetes and incident diabetes associated with periodontal disease severity.

Results—Among the individuals without prediabetes or diabetes at baseline, 38.8% (n = 1,553) had developed prediabetes and 2.2% (n = 87) had developed diabetes after six years. Nineteen percent (n = 727) of individuals with prediabetes at baseline developed diabetes after six years. Adjusting for all potential confounders, no significant association was found between periodontal disease severity and either incident prediabetes (Rate Ratio 0.93, 95% confidence interval [CI]: 0.82,1.06) or incident diabetes (Rate Ratio 0.99, 95% CI: 0.80,1.22).

Conclusions—Our findings suggest that among a diverse cohort of Hispanic/Latino individuals living in the U.S., there was no association between periodontal disease severity and the development of either prediabetes or diabetes during a six-year follow-up period.

Keywords

Periodontal Diseases; Hispanic Americans; Oral Health; Diabetes Mellitus; Type 2; Prediabetes

Diabetes mellitus is seventh among the leading causes of death in the United States (Centers for Disease Control and Prevention, 2020). Hispanic/Latino individuals, who are estimated to comprise 29% of the United States (U.S.) population by the year 2060 (Colby and Ortman 2014), experience high prevalence of health disparities and have a high risk for the common chronic diseases of type 2 diabetes and periodontal disease. The overall prevalence of diabetes among Hispanics/Latinos is estimated to be 16.9%, but varies between 10.2% to 18.3% by Hispanic/Latino background (Schneiderman et al. 2014). Periodontal disease prevalence is estimated to be 38.5% and also varies by Hispanic background group (Sanders et al. 2014). Both are chronic diseases sharing a bidirectional association marked by systemic increases in inflammatory mediators such as IL-6 and C-reactive protein (Kocher et al. 2019; Preshaw et al. 2012; Taylor 2001; Wu et al. 2020). Individuals with diabetes are likely at greater risk of developing periodontal disease and similarly, individuals with chronic periodontal disease are at greater risk of altered glycemic control (Borgnakke et al. 2013; Genco and Borgnakke 2020; Lalla and Papapanou 2011; Sanz et al. 2018).

Among adults with diabetes, 30.7% are undiagnosed and the prevalence of undiagnosed diabetes is higher among Hispanic adults (6.2%) than non-Hispanic white adults (3.9%) and non-Hispanic Black adults (4.0%) (Aviles-Santa et al. 2017; Mendola et al. 2018; Tabák et al. 2012). As such, it is critical to understand the factors that may influence the progression

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

of diabetes in Hispanic/Latinos and the early signs of disease (Casagrande et al. 2018; Demmer et al. 2012; Li et al. 2008). The American Diabetes Association (ADA) defined three diagnostic criteria for diabetes diagnosis based on the levels of fasting plasma glucose (FPG), oral glucose tolerance test (OGTT), and hemoglobin A1c (HbA1c), however there are differences in the sensitivity, variability, and reproducibility of these assays (Aviles-Santa et al. 2017). Existing evidence suggests that changes in periodontal disease status may be a reliable indicator of incident diabetes (Casanova et al. 2014).

The impact of longitudinal outcome assessments of prediabetes and diabetes incidence according to baseline periodontal disease status is equivocal due to lack of standardization across studies of periodontal disease and diagnostic criteria for incident diabetes measurements (Demmer et al. 2008a; Ide et al. 2011; Lamster et al. 2008). Studies to date have suggested that periodontal disease is an independent risk factor for the development of prediabetes and diabetes, however to our knowledge studies have yet to examine high-risk populations such as Hispanics/Latinos (Genco et al. 2020; Graziani et al. 2018). Whether periodontal disease predicts incident prediabetes and diabetes in Hispanics/Latinos is a critical question that remains unanswered.

The aim of this study was to determine if baseline periodontal disease status is independently associated with prediabetes and diabetes incidence among a large cohort of Hispanic/Latinos in the U.S. followed for six years. We hypothesized that diabetes risk in Hispanic/Latino adults varies by baseline periodontal disease status and that the incidence of diabetes would be greater in individuals with more severe periodontal disease status at baseline. This study addresses a gap in our understanding of periodontal disease severity and risk of prediabetes and diabetes in a large and diverse cohort of Hispanics/Latinos in the U.S. and adds to the literature on the temporality of the association between periodontal disease and prediabetes and diabetes associations.

MATERIALS AND METHODS

Study design, setting and participants

We analyzed data from two waves of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), a community-based prospective cohort study of 16,415 Hispanic/Latino persons aged 18–74 years, recruited from randomly selected households using a two-stage probability sampling design (Lavange et al. 2010). The population was drawn from four field centers (Chicago, IL; Miami, FL; Bronx, NY; and San Diego, CA) selected to reflect the diversity and heritage of the Hispanic/Latino population in the United States, i.e. Puerto Rican, Dominican, Mexican, Cuban, Central and South American, and mixed/other heritages. Baseline examinations were conducted during 2008–2011 along with in-person interviews. Visit 2 was conducted from October 2014 to December 2017. At the time of enrollment, standardized questionnaires were administered in English or Spanish by bilingual interviewers in the individual's preferred language (Sorlie et al. 2010). Detailed information regarding the sampling, study design, and cohort selection is available elsewhere (Sorlie et al. 2010).

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

This longitudinal study analyzed a subset of individuals in the Hispanic Community Health Study/Study of Latinos who participated in Visit 1 and Visit 2 and had a complete periodontal examination (N=10,041). Additionally, 2,037 participants with prevalent diabetes at baseline defined by glucose measurements (fasting glucose ≥126 mg/dL, 2-hour post challenge glucose ≥200 mg/dL, or hemoglobin A1C ≥6.5%) and/or anti-diabetic medication were excluded. An additional 121 participants were excluded due to missing data on key variables in the regression model, yielding a final analytic sample of 7,827.

Variables

Primary independent variable: Periodontal disease severity was assessed as follows. At the baseline visit, 18 calibrated dental examiners, assigned among the four field centers, performed comprehensive periodontal examinations on dentate individuals who did not require antibiotic prophylaxis (Sanders et al. 2014). Measurements of gingival recession and periodontal probing depths (PD) were recorded at six sites per tooth on all fully erupted permanent teeth, excluding third molars, and used to calculate the clinical attachment level (CAL), a measure of connective tissue destruction. Clinical attachment level and periodontal probing were used to classify periodontal disease severity based on the Centers for Disease Control and Prevention/American Academy of Periodontology (CDC/AAP) standardized clinical case definitions for none (no disease), mild, moderate, and severe periodontal disease (Eke et al. 2012). Periodontal disease severity was dichotomized as ‘none/mild’ and ‘moderate/severe.’

Dependent variables: Incident prediabetes was defined as fasting glucose between 100-125 mg/dL, post-challenge glucose between 140-199 mg/dL, or HbA1c between 5.7% and 6.5% at Visit 2 examination. Incident diabetes was defined as fasting glucose ≥126 mg/dL or hemoglobin A1c (HbA1c) ≥6.5%, or 2-hour post challenge glucose ≥200 mg/dL at Visit 2 examination, and/or using antidiabetic medication in the past month prior to Visit 2 examination.

Additional covariates: Baseline sociodemographic characteristics included sex (male/female), age (18-34, 35-44, 45-54, ≥55 years), Hispanic/Latino background (Mexican, Cuban, Puerto Rican, Dominican, Central American, South American, Other/Mixed), nativity status (continental U.S.-born/foreign-born), length of residence in the U.S. (less than ten years, 10-19 years, ≥20 years), annual household income (<$30,000, ≥$30,000, not reported), and education level (less than high school, high school or equivalent, greater than high school). Additional covariates included time since last dental visit (less than one year ago, one to five years ago, greater than five years ago/never), health insurance (yes/no), self-reported cigarette smoking status (never, former, current), Body Mass Index (BMI), Alternate Healthy Eating Index 2010 (AHEI-2010), and C-reactive protein level (mg/L) at baseline.

Data analysis

Descriptive statistics showing distributions of participant characteristics was performed for the overall sample and according to baseline glycemic status (normal or prediabetes). Chi-squared tests for categorical variables and Wald-tests for continuous variables were used to

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

assess the baseline distribution of key covariates by glycemic status. The crude association between baseline periodontal disease status and glycemic status at Visit 2 was assessed using a Chi-squared goodness of fit test.

To examine the association between periodontal disease severity and progression to prediabetes or diabetes we used multivariable survey Poisson regressions for complex sampling designs with duration between visits in the offset to estimate rate ratios of incident prediabetes and diabetes, while controlling for possible confounders. All analyses incorporated the sampling weights and accounted for the complex survey sampling design of the HCHS/SOL including stratification and clustering (Lavange et al. 2010). All data analyses were conducted using survey procedures in statistical software SAS 9.4 (SAS Institute Inc., Cary, NC) and SUDAAN 11.0 (Research Triangle Institute, Raleigh, NC). The significance level was set at $p<0.05$. P-values were not adjusted for multiple comparisons.

Variables associated with glycemia status in the bivariate analysis (at $p<0.10$), as well as those considered to be clinically relevant, were included in multivariable models. Three models were fit: Model 1 adjusted for factors widely associated with the outcome of diabetes or prediabetes: age, sex, Hispanic background, and BMI; Model 2 further adjusted for behavioral and demographic factors including years living in U.S., education, income, time since last dental visit, health insurance, cigarette use and diet score (AHEI-2010); and Model 3 further adjusted for logarithm transformed C-reactive protein (CRP) levels as a measure of inflammation.

Effect modification of the association of periodontal disease and incident diabetes and prediabetes by obesity status was also assessed. Indicator variables were developed for the interaction of obesity status, defined as having a BMI greater than or equal to 30, and periodontal disease, at baseline. Interaction was assessed using the list of covariates from Model 3. If statistically significant interaction was found on the multiplicative scale, we also assessed interaction on the additive scale to confirm.

The HCHS/SOL was conducted under the oversight and approval of the Institutional Review Boards of all relevant institutions and all study participants provided written informed consent prior to data collection. This study was a human observational study and adhered to the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).

RESULTS

Table 1 shows the distribution of participant characteristics for the overall study sample and according to baseline glycemic status. The prevalence of CDC/AAP-defined none or mild periodontal disease was 55.2% and moderate or severe disease was 44.8%. The 7,827 participants were predominantly female (62.8%), 43.8% of Mexican background, and had a mean age of 46 (SD 14) years. The majority had been in the U.S. ten or more years, had an annual household income less than $30,000, and had no health insurance. Among participants with no dysglycemia, 61.6% had none/mild periodontal disease and 38.4% had

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

moderate/severe periodontal disease. Individuals with BMI >30 kg/m^2 comprised 46.7% of those with prediabetes and 30.7% of those with no dysglycemia.

Table 2 is a cross-tabulation of the baseline (normal or prediabetes) and Visit 2 glycemic status (normal, prediabetes, or diabetes). Of those with no dysglycemia at baseline, 38.8% (n=1553) developed prediabetes and 2.2% (n=87) developed diabetes by Visit 2. Of those with prediabetes at baseline, the majority 68.1% (n=2603) remained at this level, and 19.0% (n=727) developed diabetes by Visit 2.

The crude association between baseline periodontal disease status, dichotomized as none/mild or moderate/severe, and Visit 2 glycemic status, categorized as normal, prediabetes, or diabetes, is shown in Table 3. Fifty-eight percent (n=2059) of participants who had moderate or severe periodontal disease had prediabetes by Visit 2, and 11.7% (n=411) had diabetes. Of the participants with mild or no periodontal disease, 48.5% (n=2097) had prediabetes and 9.3% (n=403) had diabetes by Visit 2. Chi-squared test of homogeneity found the association between baseline periodontal disease and V2 diabetes status to be significant at the 5% level ($\chi^2 = 134.09$; $df = 2$; $p < 0.0001$).

The Poisson regression models for the associations between periodontal disease severity and incident prediabetes and diabetes are shown in Table 4. A total of 47,229.19 person-years were contributed to the period of observation for incident diabetes models, and 24,295.06 person-years were contributed for incident prediabetes models. Associations between periodontal disease severity and incident prediabetes or incident diabetes were not demonstrated among our multivariable analyses.

We examined potential effect measure modification of the association between periodontal disease and incident diabetes and prediabetes by obesity status, dichotomized as having a BMI above or below 30. The interaction of moderate/severe periodontal disease and obesity was not significant for the outcome of prediabetes (Supplemental Table 1), but there was statistically significant multiplicative interaction for incident diabetes (Table 5). Individuals who had moderate or severe periodontal disease and obesity developed diabetes at 2.4 times the rate of individuals who had mild or no periodontal disease and no obesity (RR: 2.40, 95% CI: 1.79, 3.21). To confirm that this effect modification was true interaction and not a statistical artefact, we also assessed interaction on the additive scale by using the relative excess risk due to interaction (RERI), or interaction contrast (VanderWeele 2019). The RERI was −0.48, suggesting negative additive interaction.

We assessed whether participants who had moderate or severe periodontal disease were more likely to be lost to observation before Visit 2 than participants with mild or no periodontal disease. Of those who had complete Visit 1 data, including a periodontal exam, but did not have Visit 2 data, 58.5% had mild or no periodontal disease. Of participants who had complete Visit 1 and Visit 2 data, including a periodontal exam, 55.2% had mild or no periodontal disease (Table 3). We also considered whether a history of gestational diabetes would influence the trajectory from periodontal disease to incident diabetes. Among the 309 participants who reported gestational diabetes at baseline (diabetic symptoms that occurred only during pregnancy), we examined the association between periodontal disease and

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

diabetes status among a subset (n = 132) who had both complete periodontal exam and Visit 2 data. Among this subpopulation 34.9% reported moderate to severe periodontal disease, 21.2% were diagnosed with diabetes at Visit 2, and 58.3% were diagnosed with prediabetes at Visit 2. Among women in the study sample with gestational diabetes, the crude association between periodontal disease status and glycemic status at Visit 2 was not statistically significant at the 5% level ($X^2 = 4.17$, p = 0.12).

DISCUSSION

In this population-based prospective study of U.S. Hispanic/Latino adults, we found that after six years of follow-up there was no association between CDC/AAP-defined periodontal disease severity and either incident prediabetes or incident diabetes after adjusting for key confounders. While the preponderance of current evidence supports a relationship between periodontal disease and diabetes, we are aware of several longitudinal studies which also support our findings (Ide et al. 2011; Joshipura et al. 2018; Kebede et al. 2018). In an 11-year follow-up study of individuals ages 20-81 years in the Study of Health in Pomerania (SHIP) it was concluded that periodontal disease was not associated with incident diabetes although this study used alternative periodontal exposure definitions than ours (Kebede et al. 2018). In a three-year follow-up study of participants in the San Juan Overweight Adults Longitudinal Study (SOALS), full-mouth periodontal exams and multiple measures of periodontal disease were evaluated and an inverse association was shown between periodontal disease and risk of either prediabetes or diabetes (Joshipura et al. 2018).

In contrast to our findings, the most recent systematic review, which summarized observational studies exploring the bidirectional relationship between periodontal disease and diabetes, found that severe periodontitis increased the risk of type 2 diabetes by 53% (RR=1.53, 95% CI:1.27-1.83)(Wu et al. 2020). An earlier systematic review and meta-analysis, which included six studies from 2013 to 2017 (most of which were conducted in Japan and Taiwan) also concluded that individuals with periodontal disease had a higher risk (adjusted hazard ratios ranged from 1.19 to 1.33) of developing diabetes compared to individuals with no periodontal disease (Graziani et al. 2018). A well-recognized problem is that differences in the measurement of periodontal disease, as well as in the diagnostic criteria for incident diabetes, hampers direct comparisons between studies (Demmer et al. 2008b; Graziani et al. 2018). Many earlier studies used the Russell's Periodontal index (PI) and the Community Periodontal Index (CPI) which have much less stringent criteria for periodontal disease than the CDC/AAP definition. In addition, many earlier studies used self-report for diabetes and/or only fasting glucose levels for diabetes assessment in contrast to this study's robust criteria for diabetes classification.

We discovered evidence of positive multiplicative interaction by obesity in our fully adjusted model, initially suggesting that individuals with obesity and moderate or severe periodontal disease were more likely to develop diabetes than those without obesity and mild or no periodontal disease (RR: 2.40, 95% CI: 1.79, 3.21). However, after attempting to confirm interaction on the additive scale, we found evidence of negative additive interaction (RERI: −0.48). Table 5 illuminates this set of seemingly conflicting associations. The rate ratio for diabetes among individuals with mild or no periodontal disease and obesity (RR:

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

2.70, 95% CI: 2.04, 3.58) is greater than that for individuals with moderate or severe periodontal disease and obesity (RR: 2.40), both of which are substantially greater than the rate ratio for individuals with moderate to severe periodontal disease but no obesity (RR: 1.18, 95% CI: 0.82, 1.69). In other words, it is likely that obesity alone is a more significant predictor of the progression to diabetes than our main exposure, periodontal disease. Therefore, the large associations seen between obesity status and diabetes coupled with the null association between periodontal disease and diabetes result in significant positive multiplicative interaction of the periodontal disease-diabetes relationship by obesity status yet negative additive interaction, because obesity is a more significant predictor of the outcome than the main exposure of periodontal disease.

Similarly, we did not find significant interaction between moderate or severe periodontal disease and obesity for prediabetes, but the rate ratio for mild or no periodontal disease and obesity was significant (RR: 1.27, 95% CI: 1.08, 1.50), suggesting again that obesity is a more significant predictor of prediabetes than periodontal disease (Supplemental Table 1).

One concern in our analysis was differential loss to follow up, withdrawal, or death of participants before Visit 2 by periodontal disease status. We found little evidence that more severe periodontal disease would have led to selection bias through differential loss to follow up, as there was minimal difference in the proportion of those with mild or no periodontal disease between those with Visit 2 data and those lost to follow up after baseline exam.

In addition, we had a concern regarding the 132 pregnant individuals with gestational diabetes and complete Visit 2 data in our study. However, we found no differences in the association between periodontal disease and diabetes status in this group, compared to those without a history of gestational diabetes, and as such it likely had no meaningful influence on our results. In addition, there is very limited evidence to support a role of periodontal disease in gestational diabetes (Borgnakke et al. 2013; Graziani et al. 2018).

Our study had several limitations, foremost that only baseline periodontal disease measures were captured as there were no periodontal disease measures obtained at Visit 2. Therefore the effect of any interventions on periodontal disease between Visit 1 and Visit 2 was not captured. Periodontal treatment would have likely biased the findings toward the null. Another limitation was that the CDC/AAP definition of periodontal disease does not incorporate tooth loss, therefore patients with greater tooth loss might be misclassified as periodontally healthier, however it is unlikely accounting for tooth loss would have had a significant impact on our findings as the median tooth loss for our sample was two and 82.2% (n=6434) of participants reported having seven or fewer missing teeth at baseline.

This study had many strengths, notably, that this was the first study to look at the longitudinal association of periodontal disease with prediabetes and diabetes incidence among a large and diverse cohort of Hispanics/Latinos in the U.S. The prospective and population-based design included a reasonable follow-up period of six years and looked not only at older adults but at a large age range (18-74 years) including both men and women. The full mouth periodontal examinations (i.e., probing assessments at multiple sites per tooth on all teeth present) used standardized, valid measures of disease severity. We used

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

multiple, robust criteria for identifying diabetes status to inform study inclusion (use of a fasting blood glucose measure at baseline to exclude undiagnosed baseline diabetes cases). In addition, we adjusted for significant confounding factors including age, sex, Hispanic/Latino background group, body mass index, C-reactive protein, smoking status, education, income, diet score, and time since last dental visit.

In summary, our findings suggest that among individuals of Hispanic/Latino ethnicity in the U.S. there is no association between either incident prediabetes or incident diabetes with moderate or severe periodontal disease. While we did find significant evidence of interaction by obesity, it is likely because obesity is a more significant predictor of diabetes and prediabetes than periodontal disease. We suggest that additional longitudinal studies are needed generally and particularly among the Hispanic/Latino population, to better understand the relationship between periodontal disease and the development of prediabetes and diabetes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

We thank the staff and participants of HCHS/SOL for their important contributions (investigators website: http://www.cscc.unc.edu/hchs/).

FUNDING

The Hispanic Community Health Study/Study of Latinos was carried out as a collaborative study supported by contracts from the National Heart, Lung, and Blood Institute (NHLBI) to the University of North Carolina (N01-HC65233), University of Miami (N01-HC65234), Albert Einstein College of Medicine (N01-HC65235), Northwestern University (N01-HC65236), and San Diego State University (N01-HC65237). The following Institutes/Centers/Offices contribute to the HCHS/SOL through a transfer of funds to the NHLBI: National Institute on Minority Health and Health Disparities, National Institute on Deafness and Other Communication Disorders, National Institute of Dental and Craniofacial Research, National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Neurological Disorders and Stroke, and NIH Institution-Office of Dietary Supplements. Dr. Laniado was supported by a Clinical/Translational Research Career Development Award, administered by the Harold and Muriel Block Institute for Clinical and Translational Research at Einstein and Montefiore (ICTR). The study was also supported by the Life Course Methodology Core at the New York Regional Center for Diabetes Translation Research (DK111022- 8786).

DATA AVAILABILITY STATEMENT:

The data that support the findings of this study are openly available at https://biolincc.nhlbi.nih.gov/studies/hchssol/.

REFERENCES

Aviles-Santa ML, Perez CM, Schneiderman N, Savage PJ, Kaplan RC, Teng Y, Suarez EL, Cai J, Giachello AL, Talavera GA et al. 2017. Detecting prediabetes among Hispanics/Latinos from diverse heritage groups: Does the test matter? Findings from the Hispanic Community Health Study/Study of Latinos. Preventive Medicine. 95:110–118. [PubMed: 27956225]

Borgnakke WS, Ylostalo PV, Taylor GW, Genco RJ. 2013. Effect of periodontal disease on diabetes: Systematic review of epidemiologic observational evidence. J Periodontol. 84(4 Suppl):S135–152. [PubMed: 23631574]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Casagrande SS, Menke A, Aviles-Santa L, Gallo LC, Daviglus ML, Talavera GA, Castaneda SF, Perreira K, Loop MS, Tarraf W et al. 2018. Factors associated with undiagnosed diabetes among adults with diabetes: Results from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Diabetes Research and Clinical Practice. 146:258–266. [PubMed: 30419302]

Casanova L, Hughes FJ, Preshaw PM. 2014. Diabetes and periodontal disease: A two-way relationship. British dental journal. 217(8):433–437. [PubMed: 25342350]

Centers for disease control and prevention. National diabetes statistics report, 2020. Atlanta, GA: Centers for Disease Control and Prevention, U.S. Dept. of Health and Human Services; 2020.

Chapple IL, Genco R, working group 2 of the joint EFPAAPw. 2013. Diabetes and periodontal diseases: Consensus report of the joint EFP/AAP workshop on periodontitis and systemic diseases. J Periodontol. 84(4 Suppl):S106–112. [PubMed: 23631572]

Colby SL, Ortman JM. 2014. Projections of the size and composition of the U.S. Population: 2014 to 2060, Current Population Reports, p.25–1143, U.S. Census Bureau, Washington, DC.

Demmer RT, Holtfreter B, Desvarieux M, Jacobs DR Jr., Kerner W, Nauck M, Volzke H, Kocher T. 2012. The influence of type 1 and type 2 diabetes on periodontal disease progression. Diabetes Care. 35:2036–2042. [PubMed: 22855731]

Demmer RT, Jacobs DR Jr., Desvarieux M. 2008a. Periodontal disease and incident type 2 diabetes: Results from the first National Health and Nutrition Examination Survey and its epidemiologic follow-up study. Diabetes Care. 31(7):1373–1379. [PubMed: 18390797]

Demmer RT, Kocher T, Schwahn C, Volzke H, Jacobs DR Jr., Desvarieux M. 2008b. Refining exposure definitions for studies of periodontal disease and systemic disease associations. Community Dent Oral Epidemiol. 36(6):493–502. [PubMed: 18422705]

Eke PI, Page RC, Wei L, Thornton-Evans G, Genco RJ. 2012. Update of the case definitions for population-based surveillance of periodontitis. Journal of Periodontology. 83:1449–1454. [PubMed: 22420873]

Genco RJ, Borgnakke WS. 2020. Diabetes as a potential risk for periodontitis: Association studies. Periodontol 2000. 83(1):40–45. [PubMed: 32385881]

Genco RJ, Graziani F, Hasturk H. 2020. Effects of periodontal disease on glycemic control, complications, and incidence of diabetes mellitus. Periodontol 2000. 83(1):59–65. [PubMed: 32385875]

Graziani F, Gennai S, Solini A, Petrini M. 2018. A systematic review and meta-analysis of epidemiologic observational evidence on the effect of periodontitis on diabetes an update of the EFP-AAP review. J Clin Periodontol. 45(2):167–187. [PubMed: 29277926]

Ide R, Hoshuyama T, Wilson D, Takahashi K, Higashi T. 2011. Periodontal disease and incident diabetes: A seven-year study. J Dent Res. 90(1):41–46. [PubMed: 21041549]

Joshipura KJ, Munoz-Torres FJ, Dye BA, Leroux BG, Ramirez-Vick M, Perez CM. 2018. Longitudinal association between periodontitis and development of diabetes. Diabetes Res Clin Pract. 141:284–293. [PubMed: 29679620]

Kebede TG, Pink C, Rathmann W, Kowall B, Volzke H, Petersmann A, Meisel P, Dietrich T, Kocher T, Holtfreter B. 2018. Does periodontitis affect diabetes incidence and haemoglobin a1c change? An 11-year follow-up study. Diabetes Metab. 44(3):243–249. [PubMed: 29249612]

Kocher T, Holtfreter B, Petersmann A, Eickholz P, Hoffmannn T, et al. 2019. Effect of periodontal treatment on HbA1c among patients with prediabetes. Journal of Dental Research. 98(2):171–179. [PubMed: 30326764]

Lalla E, Papapanou PN. 2011. Diabetes mellitus and periodontitis: A tale of two common interrelated diseases. Nature Reviews Endocrinology. 7(12):738–748.

Lamster IB, Lalla E, Borgnakke WS, Taylor GW. 2008. The relationship between oral health and diabetes mellitus. Journal of the American Dental Association. 139 Suppl:19S–24S.

Lavange LM, Kalsbeek WD, Sorlie PD, Aviles-Santa LM, Kaplan RC, Barnhart J, Liu K, Giachello A, Lee DJ, Ryan J et al. 2010. Sample design and cohort selection in the Hispanic Community Health Study/Study of Latinos. Ann Epidemiol. 20:642–649. [PubMed: 20609344]

Li G, Zhang P, Wang J, Gregg EW, Yang W, Gong Q, Li H, Li H, Jiang Y, An Y et al. 2008. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: A 20-year follow-up study. The Lancet. 371(9626):1783–1789.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Mendola ND, Chen T, Gu Q, Eberhardt MS, Saydah S. 2018. Prevalence of total, diagnosed, and undiagnosed diabetes among adults: United States, 2013-2016. Hyattsville, MD: National Center for Health Statistics.

Preshaw PM, Alba AL, Herrera D, Jepsen S, Konstantinidis A, Makrilakis K, Taylor R. 2012. Periodontitis and diabetes: A two-way relationship. Diabetologia. 55(1):21–31. [PubMed: 22057194]

Sanders AE, Campbell SM, Mauriello SM, Beck JD, Jimenez MC, Kaste LM, Singer R, Beaver S, Finlayson TL, Badner VM. 2014. Heterogeneity in periodontitis prevalence in the Hispanic Community Health Study/Study of Latinos. Annals of Epidemiology. 24:455–462. [PubMed: 24731697]

Sanz M, Ceriello A, Buysschaert M, Chapple I, Demmer RT, Graziani F, Herrera D, Jepsen S, Lione L, Madianos P et al. 2018. Scientific evidence on the links between periodontal diseases and diabetes: Consensus report and guidelines of the joint workshop on periodontal diseases and diabetes by the International Diabetes Federation and the European Federation of Periodontology. J Clin Periodontol. 45(2):138–149. [PubMed: 29280174]

Schneiderman N, Llabre M, Cowie CC, Barnhart J, Carnethon M, Gallo LC, Giachello A, Heiss G, Kaplan RC, Lavange L. 2014. Prevalence of diabetes among Hispanics/Latinos from diverse backgrounds: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Diabetes Care. 37(8):2233–2239. [PubMed: 25061138]

Sorlie P, Aviles-Santa L, Wassertheil-Smoller S, et al. 2010. Design and implementation of the Hispanic Community Health Study/Study of Latinos. Ann Epidemiol. 20:629–641. [PubMed: 20609343]

Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. 2012. Prediabetes: A high-risk state for diabetes development. The Lancet. 379(9833):2279–2290.

Taylor GW. 2001. Bidirectional interrelationships between diabetes and periodontal diseases: An epidemiologic perspective. Annals of Periodontology. 6(1):99–112. [PubMed: 11887478]

VanderWeele TJ. 2019. The Interaction Continuum. Epidemiology. 30(5):648–658. [PubMed: 31205287]

Wu CZ, Yuan YH, Liu HH, Li SS, Zhang BW, Chen W, An ZJ, Chen SY, Wu YZ, Han B et al. 2020. Epidemiologic relationship between periodontitis and type 2 diabetes mellitus. BMC Oral Health. 20(1):204. [PubMed: 32652980]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

CLINICAL RELEVANCE

Scientific rationale:

The relationship between periodontal disease and incident prediabetes and diabetes in Hispanics/Latinos in the United States is unclear.

Principal findings:

In a large cohort of diverse Hispanics/Latinos in the United States, our findings indicate that moderate to severe periodontal disease is not associated with either incident prediabetes or incident diabetes.

Practical implications:

Although diabetes remains an epidemic and shares similar risk factors as periodontal disease, evidence to support the development of prediabetes or diabetes based on periodontal disease status could not be established for a diverse group of Hispanics/Latinos in the United States.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 1:

Baseline characteristics of study sample overall and by glycemic status (excluding prevalent diabetes), Hispanic Community Health Study/Study of Latinos (HCHS/SOL), 2008-2011, N = 7,827

	Unweighted N (weighted %)			
Characteristics	**Overall**	**No dysglycemia**	**Prediabetes**	**p-value**
Total N	7827	4007 (51.2%)	3820 (48.8%)	
Age in years				<0.0001
18-34	1851 (23.7)	1434 (35.8)	417 (10.9)	
35-44	1593 (20.4)	932 (23.3)	661 (17.3)	
45-54	2551 (32.6)	1096 (27.4)	1455 (38.1)	
55+	1832 (23.4)	545 (13.6)	1287 (33.7)	
Sex				0.02
Female	4916 (62.8)	2568 (64.1)	2348 (61.5)	
Male	2911 (37.2)	1439 (35.9)	1472 (38.5)	
Periodontal disease				<0.0001
None/mild	4323 (55.2)	2469 (61.6)	1854 (48.5)	
Moderate/severe	3504 (44.8)	1538 (38.4)	1966 (51.5)	
Hispanic/Latino Background				0.44
Dominican	649 (8.3)	330 (8.2)	319 (8.4)	
Central American	862 (11.0)	447 (11.2)	415 (10.9)	
Cuban	1084 (13.9)	531 (13.3)	553 (14.5)	
Mexican	3429 (43.8)	1767 (44.1)	1662 (43.5)	
Puerto Rican	996 (12.7)	496 (12.4)	500 (13.1)	
South American	587 (7.5)	317 (7.9)	270 (7.1)	
Mixed/Other	220 (2.8)	119 (3.0)	101 (2.6)	
Household Income				0.004
< $30,000/year	4896 (62.6)	2448 (61.1)	2448 (64.1)	
>= $30,000/year	2573 (32.9)	1352 (33.7)	1221 (32.0)	
Not reported	358 (4.6)	207 (5.2)	151 (4.0)	
Educational Attainment				<0.0001
Less than high school diploma	2631 (33.6)	1168 (29.2)	1463 (38.3)	
High school diploma	2066 (26.4)	1128 (21.2)	938 (24.6)	
Greater than HS diploma	3130 (40.0)	1711 (42.7)	1419 (37.2)	
US Nativity				<0.0001
Born in US	1315 (16.8)	833 (20.8)	482 (12.6)	
< 10 years in US	1996 (25.5)	1170 (29.2)	826 (21.6)	
10-20 years in US	1853 (23.7)	927 (23.1)	926 (24.2)	
20+ years in US	2663 (34.0)	1077 (26.9)	1586 (41.5)	
Health insurance coverage				0.01
No	4138 (52.9)	2174 (54.3)	1964 (51.4)	
Yes	3689 (47.1)	1833 (45.7)	1856 (48.6)	
Time since last dental visit				0.60

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

	Unweighted N (weighted %)			
Characteristics	**Overall**	**No dysglycemia**	**Prediabetes**	**p-value**
Within last year	4036 (51.6)	2080 (51.9)	1956 (51.2)	
Within last 1-5 years	2713 (34.7)	1368 (34.1)	1345 (35.2)	
Greater than 5 years/never	1078 (13.8)	559 (14.0)	319 (13.6)	
BMI (kg/m^2)				<0.0001
Underweight (<25)	1686 (21.5)	1153 (28.8)	533 (14.0)	
Normal weight (25-30)	3127 (40.0)	1624 (40.5)	1503 (39.4)	
Overweight (>30)	3014 (38.5)	1230 (30.7)	1784 (46.7)	
Cigarette use				<0.0001
Never	5011 (64.0)	2641 (65.9)	2370 (62.0)	
Former	1448 (18.5)	654 (16.3)	794 (20.8)	
Current	1368 (17.5)	712 (17.8)	656 (17.2)	
AHEI 2010 diet score	7827	48.3 (7.53)	50.1 (7.37)	<0.0001
log C-reactive protein	7827	0.47 (1.08)	0.87 (1.04)	<0.0001

Notes:

Abbreviations: BMI = body mass index; AHEI = Alternative Healthy Eating Index.

Periodontal disease classified as none/mild and moderate/severe based on Centers for Disease Control/American Association of Periodontology (CDC/AAP) definitions.

Count and column frequency for categorical variables, mean and standard deviation for continuous.

P-values were obtained from Chi-squared tests for categorical variables and F-tests for continuous variables.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2:

Cross-tabulation of baseline and Visit 2 glycemic status, Hispanic Community Health Study/Study of Latinos (HCHS/SOL), N = 7,827

Baseline	Visit 2			
	Normal	Prediabetes	Diabetes	Total
Prediabetes	490 (12.8%)	2603 (68.1%)	727 (19.0%)	3820 (48.8%)
Normal	2367 (59.1%)	1553 (38.8%)	87 (2.2%)	4007 (51.2%)
Total	2857 (36.5%)	4156 (53.1%)	814 (10.4%)	7827

Notes: Count data and row percentages included.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3:

Cross-tabulation of baseline periodontal disease and Visit 2 glycemic status, Hispanic Community Health Study/Study of Latinos (HCHS/SOL), N = 7,827

Baseline Periodontal Disease	Visit 2 Glycemic Status			Total	p-value
	Normal	Prediabetes	Diabetes		
None/mild	1823 (42.2%)	2097 (48.5%)	403 (9.3%)	4323 (55.2%)	
Moderate/severe	1034 (29.5%)	2059 (58.8%)	411 (11.7%)	3504 (44.8%)	
Total	2857 (36.5%)	4156 (53.1%)	814 (10.4%)	7827	<0.0001

Notes: Count data and row percentages included.

Chi-squared test of homogeneity: $\chi^2 = 134.0891$; $df = 2$

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 4:

Multivariable risk ratio (95% CI) of incident prediabetes and diabetes by periodontal disease severity, HCHS/SOL, 2008-2017

	None/mild	Moderate/severe
Incident Prediabetes (N=4,007)		
Model 1	Ref	0.96 (0.84, 1.09)
Model 2	Ref	0.94 (0.82, 1.07)
Model 3	Ref	0.93 (0.82, 1.06)
Incident Diabetes (N=7,827)		
Model 1	Ref	1.02 (0.83, 1.26)
Model 2	Ref	0.98 (0.79, 1.22)
Model 3	Ref	0.99 (0.80, 1.22)

Notes:

Results are from multivariable survey Poisson regression models.

Reference category for all models was none/mild periodontal disease based on Centers for Disease Control/American Association of Periodontology definitions.

Model 1 was adjusted for age, sex, Hispanic background, body mass index

Model 2 was further adjusted for years in US, education, income, time since last dental visit, health insurance, cigarette use, diet score.

Model 3 was further adjusted for log transformed C-reactive protein.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 5.

Multivariable rate ratios, 95% confidence intervals, and p-values of incident diabetes by baseline periodontal disease (PD) status, modified by baseline obesity status.

	Obesity (BMI ≥ 30)			No Obesity (BMI < 30)		
	Rate Ratio	**95% CI**	**p-value**	**Rate Ratio**	**95% CI**	**p-value**
Periodontal disease: Moderate/severe	2.40	1.79, 3.21	< 0.0001	1.18	0.82, 1.69	0.38
Periodontal disease: Mild/none	2.70	2.04, 3.58	< 0.0001	1.0 (ref)	--	--

Notes:

Model covariates included gender, age, Hispanic ethnicity, years spent in the United States, education, income, time since last dental visit, health insurance status, cigarette use, and log of C-reactive protein, in addition to indicator variables for the interaction of periodontal disease and obesity.