**Association Between Gum Health and Cardiovascular Disease Using Publicly Available Data from the National Health and Nutrition Examination Survey (NHANES) 2013−2014**

**Introduction**

Globally, coronary artery disease (CAD) and stroke are responsible for the largest proportion of premature deaths and disability due to atherosclerotic cardiovascular diseases (ASCVDs).[1](#_ENREF_1)over the past few centuries, improvements in the social determinants of health have not only begun to drive up the life expectancy of individuals but also the prevalence of the conventional cardiovascular disease (CVD) risk factors, such as hypertension, obesity, hyperlipidemia, and diabetes mellitus. However, despite the increasing availability of safe and highly cost-effective interventions to manage these risk factors, CVD deaths have plateaued in recent years among some of the high-income countries, including the United States.[1](#_ENREF_1)

Beyond the conventional CVD risk factors, diseases mediated by chronic inflammation and immune activation may account for the residual CVD burden that persists after the management of the conventional CVD risk factors.[2](#_ENREF_2),[3](#_ENREF_3) Although the association of periodontal disease (PD) and CVD is supported by a significant body of observational studies, the association requires further investigation as PD and CVD share a common set of modifiable risk factors, such as age, socioeconomic status, diabetes mellitus, and smoking status.[4](#_ENREF_4) We examined the relationship between PD and the prevalence of CVD (recorded as a composite of CAD and stroke) using the National Health and Nutrition Examination Survey (NHANES) 2013-2014.

**Methods**

**Study design**

This cross-sectional analysis was based on the 2013-2014 NHANES data set from a group of adult participants who underwent a home interview followed by a standardized assessment at a mobile examination center (<https://www.cdc.gov/nchs/nhanes/>). The National Center for Health statistics (NCHS) of the Center for Disease Control and Prevention conducts the NHANES survey annually to assess the health and nutritional status of the non-institutionalized U.S. civilian population through interviews, physical examination, and laboratory testing.

To produce meaningful and generalizable data on the risk factors and prevalence of major diseases in the US, participants were selected through a stratified, multi-stage probability sampling design. The NHANES study was approved by the NCHS Ethics Board, and each participant signed a written informed consent form. The Tufts University/Tufts Medical Center Institutional Review Board approved this analysis in accordance with the use of de-identified, publicly available health data.

**Periodontal Examination**

The NHANES 2013-2014 periodontal examinations were conducted at the Mobile Examination Center by dentists (D.D.S./D.M.D.) licensed in at least one U.S. state. Participants were at least 30 years old with one or more natural teeth and no health conditions requiring antibiotic prophylaxis before periodontal probing and were therefore eligible for periodontal examinations. Participants who reported a history of heart transplants, an artificial heart valve, congenital heart disease (not including mitral valve prolapse), or bacterial endocarditis were excluded based on the 2008 American Dental Association guidelines. The parameter used for this study was calculated attachment loss (AL), which was reported in millimeters (mm) and calculated by subtracting the distance from the free gingival margin to the bottom of the sulcus (FGM to sulcus base measurement) from the distance from the free gingival margin to the cementoenamel (FGM to CEJ measurement). Instead of gingival bleeding or probing depth, which reveals current disease activity, AL was used in this analysis because it indicates the cumulative loss of support from the aggregate effects of pathological factors.

Under the previous internationally accepted classification scheme from Armitage (1999),[5](#_ENREF_5) periodontitis was recognized as either chronic or aggressive; hence, all cases are now grouped in a single category and are further characterized using a multi-dimensional staging (severity of disease) and grading (progression of disease) system based on the Consensus Report from the 2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions.[6](#_ENREF_6)A patient is a periodontitis case if the interdental AL is detectable at ≥2mm for non-adjacent teeth. Stage I and II are determined using interdental AL at the tooth site of greatest loss, either 1 – 2mm or 3 – 4mm, accordingly. Stage III and IV are determined using interdental AL at the tooth site of greatest loss ≥5mm. Stage IV specifically indicates more complex cases and the need for complicated interdisciplinary oral rehabilitation due to masticatory dysfunction.[7](#_ENREF_7)

Only one participant did not have periodontal disease staging in the final sample, so this person was excluded from the analysis.

**Outcome measure**

In this analysis, the outcome of interest was a composite of two self-reported questions on the NHANES questionnaire: whether a health professional had ever told the individual that they had coronary heart disease, or if a health professional had told the individual that they had a stroke. If the participant did not know the answer to either of these questions or the result was missing, the outcome was coded as missing and the participant was dropped from this analysis. These questions were only offered to those 20 years of age and older (Figure 1).

**Variables**

The respondents’ sequence number, sex, age in years at baseline, race/ethnicity, educational level, marital status, masked variance pseudo-PSU, masked variance pseudo-stratum, and annual household income were obtained from the demographics data. Each of these variables, except for sex, were rescaled during data processing and management. Age in years at baseline, which was a continuous variable, was categorized into <65 and ≥65 years while race/ethnicity was recategorized into non-Hispanic white versus non-white persons. Annual household income was recategorized into five categories, while educational level (<high school and ≥high school) and marital status (ever married versus never married) into two categories each.

Body mass index (BMI) (defined as the participant’s weight in kg/m2), blood pressure measurements, and periodontal examination were obtained from the physical examination data. Self-reported physician-diagnosed hypertension, dyslipidemia, diabetes mellitus (DM), and chronic kidney disease (CKD), as well as self-reported smoking cigarette status, alcohol consumption, physical activity, and oral health status, were obtained from the questionnaire data. Self-reported smoking was recategorized from three (current, former, and never) to two (current cigarette smoking or no) groups. The other variables were coded in binary (yes or no) format, except for self-rated oral health status (for which five categories were created) and BMI and physical activity (used as continuous variables). Laboratory values were obtained from the laboratory data.

Patients who had missing data on the outcome, any of the self-reported variables of interest, and PD stages were excluded from this analysis.

**Statistical Analysis**

Given that a complex sampling design was used to collect the data as a part of the NHANES 2013−2014 survey, weighted statistical analysis was conducted using the physical examination sample weights. Continuous variables were summarized using weighted mean ± standard deviation (SD), while categorical variables were summarized using weighted frequency and percentages. For statistical test of imbalance, we used F-tests for all selected variables (using the Surveyreg procedure in Stata for continuous data and the tabulate command with appropriate adjustment for the survey weights). Univariable and multivariable logistic regressions were conducted to estimate the odds ratio (OR) and 95% confidence interval (CI) of having coronary artery disease and stroke with p < 0.05 considered significant.

In the multivariable logistic regression analysis, we adjusted for age, sex, race/ethnicity, marital status, educational level, annual household income, BMI, current cigarette smoking, DM, hypertension, dyslipidemia, CKD, alcohol use, and physical activity. We evaluated the goodness-of-fit for the two regression models with 10 groups using Archer-Lemeshow tests. All data processing and management and statistical analyses were performed using Stata/MP version 16.1 software (SataCorp, College Station, Texas) and codes for re-running the analysis is available at http://www.github.com/ericdunipace/periodontal.

**Results**

**References**

**1.** Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, Ahmed M, Aksut B, Alam T, Alam K, Alla F, Alvis-Guzman N, Amrock S, Ansari H, Ärnlöv J, Asayesh H, Atey TM, Avila-Burgos L, Awasthi A, Banerjee A, Barac A, Bärnighausen T, Barregard L, Bedi N, Belay Ketema E, Bennett D, Berhe G, Bhutta Z, Bitew S, Carapetis J, Carrero JJ, Malta DC, Castañeda-Orjuela CA, Castillo-Rivas J, Catalá-López F, Choi JY, Christensen H, Cirillo M, Cooper L, Jr., Criqui M, Cundiff D, Damasceno A, Dandona L, Dandona R, Davletov K, Dharmaratne S, Dorairaj P, Dubey M, Ehrenkranz R, El Sayed Zaki M, Faraon EJA, Esteghamati A, Farid T, Farvid M, Feigin V, Ding EL, Fowkes G, Gebrehiwot T, Gillum R, Gold A, Gona P, Gupta R, Habtewold TD, Hafezi-Nejad N, Hailu T, Hailu GB, Hankey G, Hassen HY, Abate KH, Havmoeller R, Hay SI, Horino M, Hotez PJ, Jacobsen K, James S, Javanbakht M, Jeemon P, John D, Jonas J, Kalkonde Y, Karimkhani C, Kasaeian A, Khader Y, Khan A, Khang YH, Khera S, Khoja AT, Khubchandani J, Kim D, Kolte D, Kosen S, Krohn KJ, Kumar GA, Kwan GF, Lal DK, Larsson A, Linn S, Lopez A, Lotufo PA, El Razek HMA, Malekzadeh R, Mazidi M, Meier T, Meles KG, Mensah G, Meretoja A, Mezgebe H, Miller T, Mirrakhimov E, Mohammed S, Moran AE, Musa KI, Narula J, Neal B, Ngalesoni F, Nguyen G, Obermeyer CM, Owolabi M, Patton G, Pedro J, Qato D, Qorbani M, Rahimi K, Rai RK, Rawaf S, Ribeiro A, Safiri S, Salomon JA, Santos I, Santric Milicevic M, Sartorius B, Schutte A, Sepanlou S, Shaikh MA, Shin MJ, Shishehbor M, Shore H, Silva DAS, Sobngwi E, Stranges S, Swaminathan S, Tabarés-Seisdedos R, Tadele Atnafu N, Tesfay F, Thakur JS, Thrift A, Topor-Madry R, Truelsen T, Tyrovolas S, Ukwaja KN, Uthman O, Vasankari T, Vlassov V, Vollset SE, Wakayo T, Watkins D, Weintraub R, Werdecker A, Westerman R, Wiysonge CS, Wolfe C, Workicho A, Xu G, Yano Y, Yip P, Yonemoto N, Younis M, Yu C, Vos T, Naghavi M, Murray C. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. *Journal of the American College of Cardiology* 2017;70:1-25.

**2.** Mason JC, Libby P. Cardiovascular disease in patients with chronic inflammation: mechanisms underlying premature cardiovascular events in rheumatologic conditions. *European heart journal* 2015;36:482-489c.

**3.** Sumayin Ngamdu K, Adewale OO, Mallawaarachchi I, Alozie OK, Dwivedi AK, Bhatt DL. Association Between the Framingham Risk Score and Carotid Artery Intima-Media Thickness in Patients With Human Immunodeficiency Virus. *The American journal of cardiology* 2020;127:156-162.

**4.** Priyamvara A, Dey AK, Bandyopadhyay D, Katikineni V, Zaghlol R, Basyal B, Barssoum K, Amarin R, Bhatt DL, Lavie CJ. Periodontal Inflammation and the Risk of Cardiovascular Disease. *Current atherosclerosis reports* 2020;22:28.

**5.** Armitage GC. Development of a classification system for periodontal diseases and conditions. *Ann Periodontol* 1999;4:1-6.

**6.** Papapanou PN, Sanz M, Buduneli N, Dietrich T, Feres M, Fine DH, Flemmig TF, Garcia R, Giannobile WV, Graziani F, Greenwell H, Herrera D, Kao RT, Kebschull M, Kinane DF, Kirkwood KL, Kocher T, Kornman KS, Kumar PS, Loos BG, Machtei E, Meng H, Mombelli A, Needleman I, Offenbacher S, Seymour GJ, Teles R, Tonetti MS. Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *J Periodontol* 2018;89 Suppl 1:S173-s182.

**7.** Tonetti MS, Greenwell H, Kornman KS. Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. *J Periodontol* 2018;89 Suppl 1:S159-s172.