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## Risk Indicators for Periodontitis in US Adults: NHANES 2009 – 2012

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### Abstract

**Objective.**—To determine population-average risk profiles for severe and non-severe periodontitis in US adults (30 years and older) using optimal surveillance measures and standard case definitions.

**Methods.**—We analyzed data from the 2009–2012 National Health and Nutrition Examination Survey (NHANES), which for the first time used the “gold standard” full-mouth periodontitis surveillance protocol to classify severity of periodontitis following the suggested CDC/AAP case definitions. The probabilities of periodontitis by socio-demographics, behavioral factors, and co-morbid conditions, were assessed using prevalence ratios (PR) estimated by the predicted marginal probability from multivariable generalized logistic regression models. The analyses were further stratified by gender and severity of periodontitis.

**Results.**—For adults 65 years and older, the likelihood of periodontitis was greater in females (aPR=3.15; 95% CI 2.63 – 3.77) than males (aPR=2.07; 1.76 – 2.43). The likelihood of severe periodontitis was relatively level across all age groups, while non-severe periodontitis increased with age. Compared to non-Hispanic whites, periodontitis was more likely among Hispanics (aPR=1.38; 1.26–1.52) and non-Hispanic blacks (aPR=1.35; 1.22–1.50), and severe periodontitis was most likely among non-Hispanic blacks (aPR=1.82; 1.44–2.31). There was a 50% greater likelihood of periodontitis among current smokers compared to non-smokers. For females, the likelihood of periodontitis was not different between former smokers and non-smokers. Periodontitis was not more likely in persons with pre-diabetes or diabetes, but was more likely

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only among persons with un-controlled diabetes compared to persons with no diabetes and this association was restricted to only males. Periodontitis was not associated with obesity status.

**Conclusions.**—An assessment of risk profiles for periodontitis in US adults based on gold standard periodontal measures show important differences by severity of disease and gender. Cigarette smoking, specifically among current smokers remains an important modifiable risk for all levels of periodontitis severity. The higher burden of periodontitis in older women and in males with uncontrolled diabetes is noteworthy. These findings could improve the identification of target populations for effective public health interventions and improve periodontal health of US adults.

### Keywords

Periodontitis; dental research; epidemiology; oral health surveys; dental health surveys; nutrition surveys; oral health; periodontal attachment loss; population surveillance; probability; risk; tooth loss; periodontal pocket; surveillance

## Introduction

Periodontitis is a chronic disease of the hard and soft tissues supporting the teeth (Pihlstrom et al., 2005). Monitoring and reducing periodontitis in the adult US population through national disease surveillance and public health interventions is a significant concern highlighted in the Surgeon General's Report on Oral Health (USDHHS 2000b), and is an objective highlighted in Healthy People 2020 (USDHHS 2010) (Eke et al 2012c). To address this concern, it is crucial to better understand the burden and population characteristics, including modifiable and non-modifiable risk factors, associated with periodontitis in US adults.

Recent advances in surveillance of periodontitis in the US, including recent changes in the clinical examination protocols used and the development and use of standard case definitions, have improved our understanding of the burden of periodontitis in the adult population (Page and Eke, 2007; Eke et al., 2012a). Historically, representative population estimates of periodontitis for US adults were based on data from the National Health and Nutrition Examination Survey (NHANES). Prior to 2009, surveillance of periodontitis in NHANES was based on data collected by various Partial Mouth Periodontal Examination (PMPE) protocols, (Dye et al., 2007; Dye and Thornton-Evans, 2007). Identification of periodontitis cases based on PMPE measurements can result in false negatives, impacting the accuracy of prevalence estimates and risk assessments due to misclassification bias (Eke et al., 2010). Using the Full Mouth Periodontal Examination (FMPE) protocol optimizes measurements for the most accurate classification of periodontitis in surveillance. Since 2009, the NHANES has used the FMPE protocol. Similarly, standardized case definitions of periodontitis are critical to the proper characterization of true disease burden in populations, and for comparison between studies. In 2007, an expert workgroup developed and suggested standard case definitions for surveillance of periodontitis (Page and Eke, 2007; Eke et al., 2012a). Using data from the 2009–2012 NHANES and applying these case definitions, we have revised the prevalence of periodontitis in US adults, reporting for the first time direct evidence that almost 50% of the US adults aged 30 years and older have periodontitis (Eke et al., 2012b).

The availability of periodontal measures from a FMPE protocol and simultaneous collection of information on putative risk factors such as socio-demographic, behavioral, and comorbid conditions in the 2009–2012 NHANES for the first time affords the opportunity to revisit and determine a more valid population-average risk profiles for periodontitis in US adults. Several studies have previously reported putative population risk factors for periodontitis, notably socio-demographic characteristics such as age, gender, race/ethnicity, and income; risk behavior such as smoking; and co-morbid conditions such as diabetes and obesity (Albandar, 2005; Genco and Borgnakke, 2013). However, many of these risk indicator studies are subject to limitations such as using periodontitis cases determined from partial mouth periodontal measures and study samples that are not generalizable to the adult US population. (Albandar 2005; Beck and Offenbacher 2005; Genco and Borgnakke 2013). Also, these studies have often used different and inconsistent case definitions that did not capture severity of periodontitis (Albandar 2005; Beck and Offenbacher 2005; Genco and Borgnakke 2013). (Saremi 2005; Taylor 1999).

Identifying population risk factors is critical to developing effective preventative interventions of disease in populations. Thus, we analyzed data from the 2009–2012 NHANES, based on the FMPE and classification of severity of periodontitis based on the suggested Centers for Disease Control/American Academy of Periodontology (CDC/AAP) case definitions for surveillance of periodontitis, to determine population-average risk profiles for periodontitis in US adults at least 30 years of age.

## Methods

This study used the publically released NHANES 2009–2010 and 2011–2012 data. NHANES is a stratified, multistage probability sample of the civilian non-institutionalized population in the 50 states of the US and the District of Columbia. The technical details of the survey, including sampling design, periodontal data collection protocols, and data availability can be accessed at [www.cdc.gov/nchs/nhanes.htm](http://www.cdc.gov/nchs/nhanes.htm). Additional information on the oral health data collection and quality of the data during the 2009–2010 cycle are described (Dye et al., 2014). Oral health data collection protocols for the NHANES 2009–2012 were approved by the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS) Research Ethics Review Board (equivalent to Institutional Review Boards), and all survey participants provided written informed consent.

Among participants 30 years and older, periodontal examinations were conducted in a mobile examination center (MEC). Gingival recession (distance between the free gingival margin (FGM) and the cemento-enamel junction [CEJ]), followed by periodontal probing depth (PPD) (= distance from FGM to the bottom of the sulcus or periodontal pocket) were measured at six sites around each tooth (mesio-, mid-, and disto-buccal; mesio-, mid-, and disto-lingual) for all teeth, excluding third molars. For measurements at each site, a periodontal probe (Hu-Friedy PCP 2™) with 2–4–6–8–10–12mm graduations was positioned parallel to the long axis of the tooth at each site. Each measurement was rounded to the lower whole millimeter. Data were recorded directly into a NHANES oral health data management program that instantly calculated clinical attachment loss (CAL) as PPD minus gingival recession. Adults aged 30 years or older, who had one or more natural teeth and did

not have a health condition that required antibiotic prophylaxis before periodontal probing, were eligible for the periodontal examination during NHANES 2009–2012.

Periodontitis cases were defined following the suggested CDC/AAP case definitions for surveillance of periodontitis (Page and Eke 2007, Eke et al 2012a). *Severe periodontitis* was defined as having two or more interproximal sites with  $\geq 6$  mm CAL (not on the same tooth) AND one or more interproximal site(s) with  $\geq 5$  mm PPD. Second, *non-severe periodontitis* combined two levels of disease: moderate periodontitis, defined as two or more interproximal sites with  $\geq 4$  mm clinical CAL (not on the same tooth) OR two or more interproximal sites with PPD  $\geq 5$  mm, but not on the same tooth; and mild periodontitis, defined as  $\geq 2$  interproximal sites with  $\geq 3$  mm CAL and  $\geq 2$  interproximal sites with  $\geq 4$  mm PPD (not on the same tooth) or 1 site with  $\geq 5$  mm. Both categories are not truly ordinal as the label suggests because many of the “moderate” cases had insufficient pocket depth to qualify as “mild” and therefore we combined them under the label “non-severe” periodontitis (Eke et al, 2015). Finally, *Total periodontitis* (reported as periodontitis) was defined as the presence of severe or non-severe periodontitis.

Consistent with previous studies (Borrell and Crawford, 2011, 2012; Dye et al., 2007; Genco and Borgnakke, 2013), we selected for our analyses previously reported potential socio-demographic, behavior and co-morbid risk indicators for periodontitis. Age (categorized as 30 – 44, 45 – 54, 55 – 65, and  $> 65$ ) and gender (male/female) were included in the analyses as collected by NHANES. Race/ethnicity was analyzed in four groups: non-Hispanic Whites, non-Hispanic Blacks, Hispanics (i.e., anyone who self-identifies as “Hispanic” which is a combination of Mexican-Americans and other Hispanics, of which the majority self-identify as Mexican-Americans), and other race/ethnicity, including multi-racial. Education was classified as less than high school, high school graduate or General Education Development (GED) high school equivalency test, and greater than high school. Poverty status categories or percentage of poverty relative to the federal poverty levels were derived from family income, family size, and the number of children in the family for families with two or fewer adults, and on the ages of the adults in the household. The poverty level was based on definitions originally developed by the Social Security Administration (Fisher 1992). Families or individuals with income below their appropriate thresholds are classified as below the Federal Poverty Level (FPL). These thresholds are updated annually by the U.S. Census Bureau (<http://aspe.hhs.gov/poverty/11poverty.shtml>). Marital status was self-reported married, divorced or separated, widowed, living with a partner, and single/never married.

Smoking status was constructed from responses to two questions: (1) *Have you smoked at least 100 cigarettes in your life?* and (2) *Do you now smoke cigarettes?* Respondents who reported smoking every day or some days and had smoked at least 100 cigarettes were categorized as current smokers; respondents who reported currently not smoking but having smoked more than 100 cigarettes in the past were categorized as former smokers; and respondents who reported not having smoked at least 100 cigarettes were categorized as non-smokers.

Diabetes status was defined by self-report, levels of fasting plasma glucose (FPG) or blood levels of glycosylated hemoglobin A1c (HbA<sub>1c</sub> or A<sub>1c</sub>). Participants who responded “Yes” to the question “have you ever been told by your doctor or other care provider that you had diabetes?” were considered to have diagnosed diabetes, and those who answered “No” were classified as not diagnosed. Un-controlled diabetes was defined as diagnosed diabetes and FPG  $\geq$  126 mg/dL or HbA<sub>1c</sub>  $\geq$  7.0; controlled diabetes was defined as diagnosed diabetes and FPG <126 mg/dL or HbA<sub>1c</sub> < 7.0; pre-diabetes was defined as no diagnosed diabetes and 100  $\leq$  FPG < 126 mg/dL or 5.7  $\leq$  HbA<sub>1c</sub> < 6.5; and non-diabetes was defined as self-reported no diagnosed diabetes and FPG < 100 mg/dL or HbA<sub>1c</sub> < 5.7. Un-diagnosed diabetes was defined as no diagnosed diabetes and FPG  $\geq$  125 or HbA<sub>1c</sub>  $\geq$  7.0. Duration of diabetes was categorized as 0 – 2, 3 – 6, 7 – 10, 11 – 17 and > 18 years, since told by a doctor you had diabetes. Body mass index (BMI) was used to determine levels of obesity status. An individual with BMI  $\geq$  30 was considered obese, between 25 - < 30 overweight, between 18.5 - < 25 normal weight, and <18.5 as underweight (Keys 1972, CDC 2011).

In NHANES 2009–2012, adults aged 30 years or older with at least one natural tooth and not suffering from any health condition requiring antibiotic prophylaxis prior to periodontal probing were eligible for the periodontal examination yielding a combined total of 9402 adults aged 30 years. Out of these, 1,631 were excluded from the oral health assessment in the MEC due to medical exclusions or did not complete their examination, and 705 were identified as edentulous (edentate, having no teeth) and were excluded. Our analyses were based on the remaining 7,066 participants representing a weighted population of approximately 141.0 million civilian non-institutionalized American adults 30 years of age and older, and further restricted the analysis to respondents with non-missing values for all covariates and the dependent variable (see footnote for each table for sample size).

Descriptive statistics were calculated by severity of periodontitis (i.e., severe and non-severe periodontitis, and total periodontitis) and by gender. Our preliminary analyses suggested that gender modified the effect of several putative risk factors on periodontitis hence we further stratified our analyses by gender. Accounting for the high prevalence (> 10%) in the US adult population, we used Prevalence Ratios (PR) to avoid overestimation of the association between each exposure and periodontitis. All analyses were conducted using SAS-callable SUDAAN and NHANES MEC examination weights to account for complex survey sampling design. The adjusted weighted predicted prevalence ratios (PR) and 95% confidence interval (CI) for the likelihood of having periodontitis (Total, severe or non-severe) by selected co-variates was calculated using (Proc RLOGIST) log-linear regression models.

## Results

Overall, a total of 46% US adults aged 30 and older had periodontitis, distributed as 8.9% with severe periodontitis and 37.1% with non-severe periodontitis. More males than females had severe periodontitis (13.3% vs. 4.7%) and non-severe periodontitis (41.6% vs. 32.7%). The study population was about evenly distributed by gender (51% females), but more males than females were current and former smokers, had diabetes and were overweight (Table 1).

Using multi-variable analyses (Table 2), the likelihood of having periodontitis or non-severe periodontitis increased steadily with increasing age, while the likelihood of having severe periodontitis was relatively level across age groups. By gender, the likelihood of severe periodontitis was two times more likely among males compared to females (aPR=2.68, 2.22 – 3.23). By race/ethnicity, having periodontitis was most likely among Hispanics (aPR=1.38; 1.26–1.52) and non-Hispanic blacks (aPR=1.35; 1.22–1.50) compared to non-Hispanic whites, and severe periodontitis was most likely among non-Hispanic blacks (aPR=1.82; 1.44–2.31). Periodontitis did not vary significantly by education. Overall, there was a steady increase in the likelihood of periodontitis with increasing poverty (lower FPL). Periodontitis was significantly more likely among current and formers smokers compared to non-smokers. The risk for periodontitis was highest among current smokers (aPR 1.54, 1.45 – 1.65), and smoking was more strongly associated with severe forms of periodontitis (aPR = 2.46, 1.87 – 3.24). By diabetes status, periodontitis was more likely in persons with un-controlled diabetes, specifically among those with severe periodontitis (aPR = 1.42, 1.02 – 1.98) and this association was restricted to only males. Finally, the likelihood of periodontitis did not significantly vary by obesity status (i.e., normal weight, overweight and obese).

When stratified by gender (Table 3, figures 1 a–c), periodontitis and non-severe periodontitis were more likely among females 65 years and older. Periodontitis was equally likely in female former smokers and non-smokers. In females, periodontitis and non-severe periodontitis were not significantly associated with diabetes status. In males, all levels of severity of periodontitis were more likely among un-controlled diabetes when compared with persons without diabetes.

Further analyses of periodontitis and diabetes also suggested that the duration of diabetes did not significantly correlate with the likelihood of periodontitis after adjusting for all covariates. Similarly, no trend was observed between periodontitis and fasting glucose amongst persons with diabetes. In females without diabetes, total periodontitis and non-severe periodontitis (but not severe periodontitis) significantly increased with increasing levels of fasting glucose levels. In males without diabetes, no trend was observed for any level of severity of periodontitis and increasing fasting glucose levels. Periodontitis were significantly associated with increasing levels of HbA<sub>1c</sub> in both male and females without diabetes. Among persons with diabetes, only severe periodontitis was significantly correlated with increasing levels of HbA<sub>1c</sub> in males (results not included).

## Discussion

This study finds new and important risk profiles for periodontitis by severity of periodontitis and gender. Notably, we report differences in the likelihood of non-severe periodontitis and severe periodontitis by increasing age, and a greater likelihood of periodontitis in older females than males (> 65 years old). While the probability of periodontitis was consistently associated with current smoking, we find that periodontitis was only significant in male former smokers and not in females. Periodontitis was not more likely in persons with controlled diabetes, only more likely among males with uncontrolled diabetes. Among females, this relationship was observed only between severe periodontitis and uncontrolled

diabetes. Finally, this study did not find that periodontitis was more likely associated with obesity status regardless of gender.

In this study, we report a higher likelihood of periodontitis in older women compared to males at 65 years old. This finding is not widely recognized in periodontal epidemiology even though a similar US national study had also reported that older men had better periodontal status than females (Albandar, 2002). The higher likelihood of periodontitis in older women can be attributed to women keeping more of their teeth and a possible higher prevalence of tooth loss in males, and also that older women at this age are likely to be post-menopausal when production of estrogen has decreased. Lower estrogen production has been associated with increased risk for periodontitis (Friedlander, 2002). In 2000, approximately 45.6 million women in the United States were in the postmenopausal phase of life, and more women are living beyond 65 (USDHHS 2000a; US census 2002). Gender dimorphism is known for several chronic diseases and a recent study on the classification of periodontitis based on gene expression has demonstrated that severity and extent of periodontitis are most strongly linked with gender compared to other putative risk factors for periodontitis (Kebuschull et al., 2014, Alam, Misha and Chandrasekaran, 2012).

Consistent with previous studies, we find that the likelihood of periodontitis is highest among current smokers (Albandar 2002, Tomar and Asma 2000). The likelihood of periodontitis dropped significantly among former smokers, and was not significantly different from non-smokers in females. This finding supports the potential benefits of smoking cessation in preventing and controlling periodontitis. In 2013, an estimated 1 in 5 (17.8%) of US adults were current smokers (CDC, 2014, Agaku et al., 2014). Also, it is worth noting that we reported a higher but non-significant likelihood for periodontitis among female current smokers compared to men. Postmenopausal female smokers have been reported to experience more severe alveolar bone loss than non-smokers, as smoking and osteoporosis/osteopenia combine to exacerbate bone loss (Payne JB et al., 2000).

Our determination of diabetes status was based on results from actual laboratory tests of fasting plasma glucose and HbA<sub>1c</sub>, an objective measure of diabetes. Whereas relationships between periodontitis and diabetes have been widely reported in clinical studies conducted among persons with diabetes, evidence for this association by severity of disease and by gender at the population level is scarce. Our findings are consistent with reports that severe periodontitis is more prevalent in people with diabetes. Specifically, about one-third of people with diabetes have severe forms of periodontal disease and adults aged 45 years or older with poorly controlled diabetes are three times more likely to have severe periodontitis than those without diabetes (Saremi et al, 2005., Taylor, Loesche and Terpenning 2000). Also, a recent prospective population study similarly report significant relationships between periodontitis and diabetes only in persons with uncontrolled diabetes (Demmer et al., 2012).

In the US population, 9.3% of adults have diagnosed (21.0 million) and undiagnosed (8.1 million) diabetes, with 12.3% of adults aged 20 and over having diabetes (CDC, 2014). Among the latter with diagnosed diabetes, about 86% use insulin (14%), anti-diabetes oral medication (57%) or both (15%), so only about 14% do not take medications to control their diabetes (CDC 2014). This distribution may help explain our findings of no significant

risk for periodontitis associated with controlled diabetes, and may indicate that the risk is mediated by the level of successful diabetes management that decreases the proportion of uncontrolled diabetes cases in the US population.

We report no increased likelihood of periodontitis associated with obesity status regardless of gender or severity of periodontitis. This finding is consistent with the finding for another recent population-based study (de Castilos et al., 2012.). However, a recent systemic review of five studies reported an association between weight gain and obesity and higher risk for new incident cases of periodontitis. Notably, the US population studies included in this review used self-report periodontitis and a single measure of probing depth as the outcome. The importance of obesity to and its influence on periodontitis is attributed to BMI being a main risk factor for pre-diabetes (Arora et al., 2014). In this study, we did not find an increase likelihood of periodontitis among pre-diabetes. While some studies have implicated obesity as a putative risk factor for periodontitis, we find that most of these studies were conducted in hospital patients or in small samples (Moura-Grec et al 2014, Palle 2013).

We confirm that several socioeconomic indicators, such as race/ethnicity, poverty level, and education, are associated with increased risk for periodontitis and therefore may account for disparities in periodontitis across US adult communities. For these indicators however, we did not find that the effects were modified by gender. Borrell and Crawford have discussed how these socioeconomic variables interact to influence racial/ethnic disparities in populations (Borrell and Crawford 2012). Particularly, they conclude that periodontal disease is inversely related to education and income after controlling for age and gender, and that the differences in education and income explain most, if not all, of the observed disparities in periodontitis by race and ethnicity.

This study has some notable limitations. The study is cross-sectional and therefore does not allow any deduction of causality. The included population was limited to adults 30 years and older and did not include institutionalized persons, such as older adults in nursing home settings and adults in prisons, which may introduce some selection bias. There are possibilities of misclassified periodontitis cases because third molars were excluded, furcation involvement status and bleeding upon probing were not assessed (a parameter that could indicate active inflammation). Finally, a small number of non-severe cases may be misclassified as non-cases based on the classification criteria used.

In conclusion, this study using optimal surveillance measures and standardized case definitions, provides new information on potential risk indicators for public health action to prevent periodontitis in the contemporary US adult population 30 years and over. Cigarette smoking, specifically current smoking remains an important modifiable risk for all levels of periodontitis severity. The higher burden of periodontitis in older women and the differences in potential risk profiles for severe and non-severe periodontitis by gender and co-morbid conditions (i.e. uncontrolled diabetes) is noteworthy, especially in light of the higher burden of multiple chronic conditions occurring in women compared to men (Lochner and Cox, 2013). Our findings provides potential areas of focus to prevent and control periodontitis to improve the oral health, general health and wellbeing of our adults US population.



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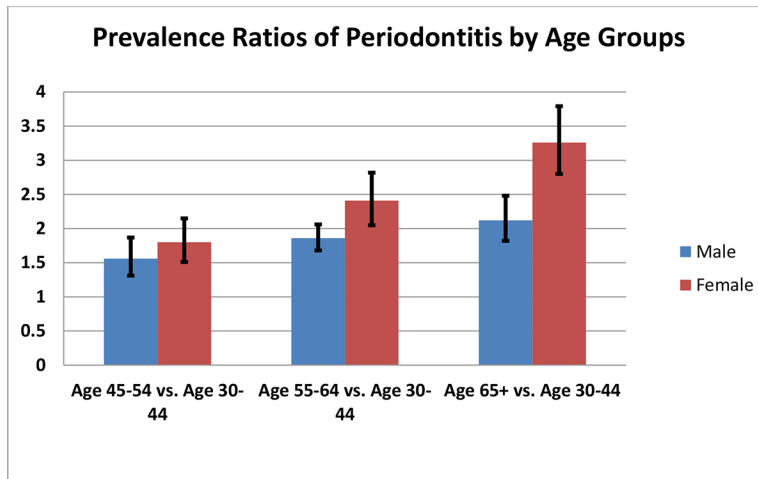


Figure 1a

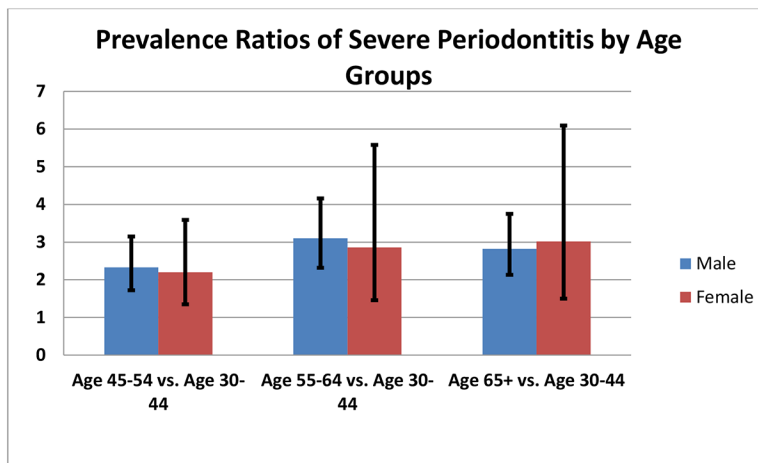


Figure 1b

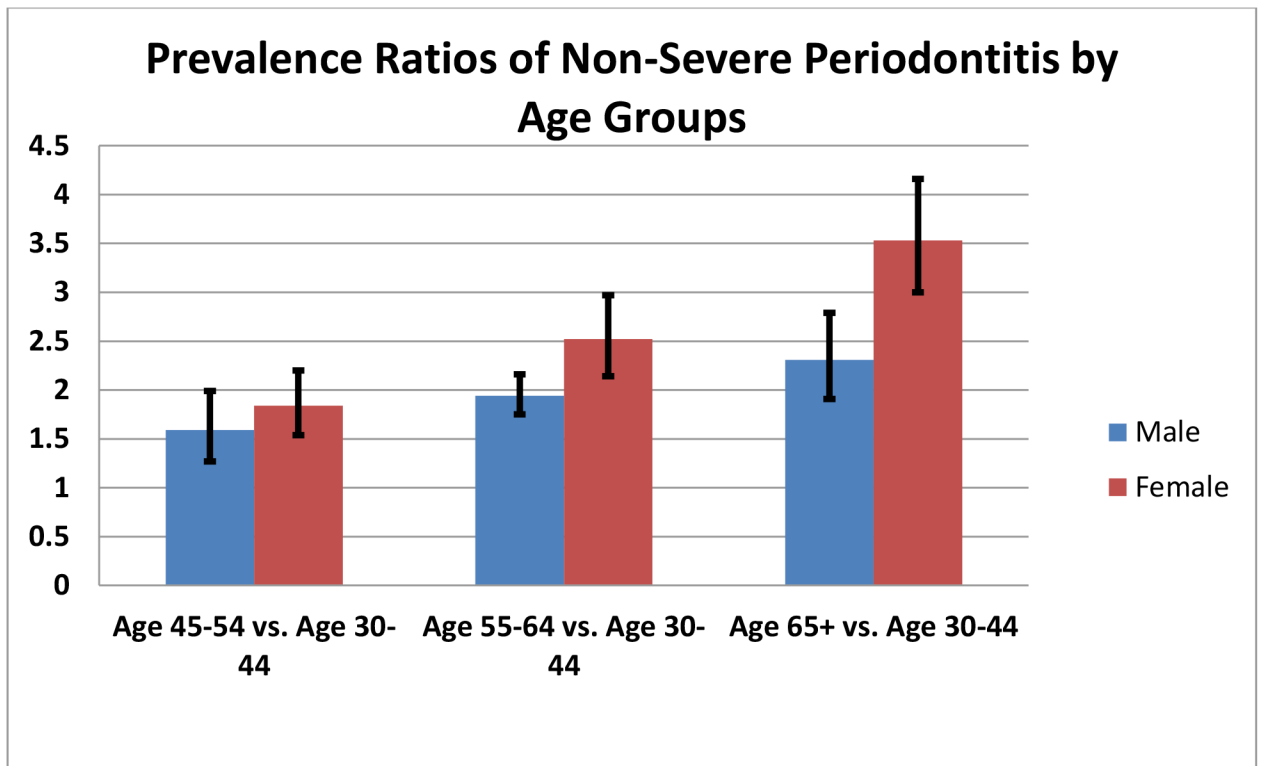


Figure 1c

**Figure 1.** Prevalence ratios by age groups and sex: A) TP; B) SP; and C) NSP (mild or moderate).

**Table 1.**

Population Characteristics and Unadjusted Prevalence Ratios for Periodontitis among US adults 30 years and older: NHANES 2009–2012

Groups	N	Weighted N (in millions)	Percent	SE	Male	Female	Total Periodontitis Crude PR (95% CI)	Severe Periodontitis Crude PR (95% CI)	Non-Severe Periodontitis Crude PR (95% CI)
CDC Severe	879	12.5	8.9	0.59	13.3	4.7			
CDC Non-Severe	3005	52.2	37.1	1.51	41.6	32.7			
CDC Non Cases	3182	76.2	54.0	1.60	45.1	62.6			
Total	7066	140.9	100.0		100.0	100.0			
Age Groups									
Age 65+	1511	23.8	16.9	0.81	16.1	17.6	2.21(1.98–2.47)	2.26(1.75–2.93)	2.35(2.08–2.66)
Age 55–64	1397	28.1	19.9	0.77	19.5	20.3	1.79(1.63–1.96)	2.58(2.03–3.30)	1.78(1.60–1.98)
Age 45–54	1619	36.0	25.6	0.74	25.6	25.6	1.52(1.34–1.73)	2.19(1.77–2.70)	1.49(1.27–1.74)
Age 30–44 (Ref)	2539	53.0	37.6	1.31	38.8	36.5			
Gender									
Male	3515	69.0	49.0	0.64	NA	NA	1.47(1.37–1.58)	2.84(2.29–3.53)	1.40(1.29–1.51)
Female (Ref)	3551	71.9	51.0	0.64	NA	NA			
Race/Ethnicity									
Hispanics	1774	18.8	13.4	1.81	13.8	12.9	1.45(1.30–1.62)	1.89(1.47–2.43)	1.45(1.29–1.63)
NH Black	1512	15.1	10.7	1.16	9.8	11.7	1.45(1.29–1.64)	2.31(1.72–3.09)	1.41(1.24–1.62)
Others	762	10.0	7.1	0.74	6.7	7.6	1.26(1.09–1.47)	1.73(1.17–2.57)	1.24(1.04–1.47)
NH White (Ref)	3018	97.0	68.8	2.41	69.7	67.8			
Education									
< High School	1784	23.1	16.4	1.04	17.0	15.8	1.80(1.64–1.98)	2.98(2.46–3.61)	1.81(1.61–2.02)
High School	1514	29.5	20.9	0.99	21.9	20.0	1.50(1.39–1.62)	2.08(1.63–2.64)	1.49(1.36–1.63)
>High School (Ref)	3757	88.3	62.7	1.52	61.1	64.2			
Poverty Level									
Missing Value on FPL	618	9.6	6.8	0.55	6.5	7.1	1.65(1.42–1.91)	2.41(1.46–3.97)	1.63(1.39–1.92)
Less than 100% FPL	1257	15.5	11.0	0.72	10.2	11.7	1.89(1.67–2.13)	3.00(2.11–4.28)	1.89(1.64–2.17)
100–199% FPL	1683	24.9	17.7	0.89	17.1	18.2	1.73(1.58–1.88)	2.76(1.97–3.87)	1.70(1.54–1.88)
200–399% FPL	1660	37.6	26.6	1.45	26.5	26.8	1.46(1.27–1.68)	1.63(1.14–2.33)	1.48(1.28–1.71)
400% FPL (Ref)	1848	53.4	37.9	1.54	39.6	36.2			
Marital Status									
Married	4049	88.4	62.7	1.04	65.3	60.2	0.93(0.82–1.06)	0.95(0.67–1.35)	0.93(0.81–1.06)

Groups	N	Weighted N (in millions)	Percent	SE	Male	Female	Total Periodontitis Crude PR (95% CI)	Severe Periodontitis Crude PR (95% CI)	Non-Severe Periodontitis Crude PR (95% CI)
Divorced or Separated	1170	20.9	14.9	0.59	12.6	17.0	1.23(1.08–1.39)	1.71(1.20–2.44)	1.20(1.03–1.39)
Widowed	525	7.3	5.2	0.26	2.4	7.8	1.37(1.15–1.63)	1.42(0.94–2.15)	1.41(1.17–1.70)
Living with Partner	495	9.5	6.7	0.50	7.9	5.7	1.21(1.01–1.43)	1.62(1.15–2.29)	1.18(0.97–1.44)
Never Married (Ref)	821	14.8	10.5	0.69	11.9	9.2			
Smoking									
Current Smoker	1338	24.6	17.4	0.62	20.5	14.5	1.74(1.63–1.85)	3.45(2.78–4.29)	1.69(1.58–1.82)
Former Smoker	1769	37.0	26.3	1.12	29.5	23.2	1.27(1.18–1.37)	1.74(1.28–2.35)	1.25(1.15–1.35)
Non-Smoker (Ref)	3956	79.3	56.3	1.01	50.0	62.3			
Diabetes									
Diabetes Not Controlled	481	7.1	5.0	0.35	5.7	4.4	1.72(1.55–1.92)	2.13(1.64–3.27)	1.77(1.55–2.02)
Diabetes Controlled	733	10.7	7.6	0.39	8.3	6.9	1.67(1.52–1.83)	2.12(1.48–3.04)	1.71(1.53–1.92)
Pre-Diabetes	1904	33.9	24.0	0.62	23.2	24.8	1.43(1.31–1.55)	1.66(1.34–2.06)	1.45(1.32–1.59)
Non-Diabetes (Ref)	3948	89.3	63.4	0.79	62.8	63.9			
BMI Groups									
Obese	2690	51.4	37.1	1.02	35.9	38.2	1.11(1.02–1.21)	0.98(0.77–1.25)	1.14(1.03–1.28)
Overweight	2464	50.5	36.4	0.87	41.4	31.6	1.09(1.00–1.19)	1.06(0.81–1.39)	1.11(0.99–1.23)
Normal Weight (Ref)	1790	36.8	26.5	0.85	22.8	30.2			

For Non-Severe Periodontitis, severe cases were excluded from the denominator. NA=not applicable.

**Table 2.**

Prevalence Ratios of Periodontitis by Socio-demographic factors, Smoking, and co-morbid conditions:  
NHANES 2009–2012

Effect	Total Periodontitis (N=6924)		Severe Periodontitis (N=6924)		Non-Severe Periodontitis (N=6061)	
	PR (95% CI)	P-Value	PR (95% CI)	P-Value	PR (95% CI)	P-Value
Age 65+ vs. Age 30–44	2.46(2.14–2.82)	<0.0001	2.61(1.88–3.62)	<0.0001	2.73(2.34–3.19)	<0.0001
Age 50–64 vs. Age 30–44	2.01(1.80–2.24)		2.80(2.07–3.79)		2.13(1.90–2.40)	
Age 45–54 vs. Age 30–44	1.62(1.41–1.87)		2.22(1.78–2.77)		1.66(1.41–1.96)	
Male vs. Female	1.47(1.38–1.58)	<0.0001	2.68(2.22–3.23)	<0.0001	1.47(1.36–1.58)	<0.0001
Hispanics vs. NH Whites	1.38(1.26–1.52)	<0.0001	1.56(1.23–2.00)	<0.0001	1.44(1.29–1.60)	<0.0001
NH Blacks vs. NH Whites	1.35(1.22–1.50)		1.82(1.44–2.31)		1.36(1.19–1.54)	
Others vs. NH Whites	1.34(1.19–1.51)		1.69(1.16–2.45)		1.37(1.19–1.58)	
<High School vs. > High School	1.29(1.17–1.42)	<0.0001	1.63(1.26–2.12)	0.0015	1.29(1.15–1.45)	<0.0001
High School vs.>High School	1.20(1.12–1.30)		1.50(1.14–1.98)		1.21(1.10–1.32)	
Missing FPL vs. >=400% FPL	1.27(1.10–1.48)	<0.0001	1.69(1.03–2.77)	0.0347	1.26(1.07–1.49)	<0.0001
Less than 100% FPL vs. >=400% FPL	1.41(1.25–1.59)		1.71(1.14–2.57)		1.44(1.26–1.65)	
100–199% FPL vs. >=400% FPL	1.35(1.23–1.48)		1.82(1.22–2.71)		1.36(1.22–1.52)	
200–399% FPL vs. >=400% FPL	1.25(1.12–1.39)		1.31(0.91–1.90)		1.27(1.13–1.44)	
Married vs. Never Married	0.96(0.87–1.06)	0.0301	1.09(0.78–1.52)	0.0866	0.93(0.83–1.04)	0.1063
Divorced vs. Never Married	1.10(0.99–1.23)		1.44(1.02–2.04)		1.05(0.92–1.20)	
Widowed vs. Never Married	0.92(0.77–1.11)		1.15(0.76–1.75)		0.88(0.72–1.09)	
Living with Partner vs. Never Married	1.06(0.91–1.23)		1.21(0.86–1.69)		1.04(0.87–1.25)	
Current Smoker vs. Non Smoker	1.54(1.45–1.65)	<0.0001	2.46(1.87–3.24)	<0.0001	1.56(1.44–1.68)	<0.0001
Former Smoker vs. Non Smoker	1.09(1.02–1.17)		1.39(1.03–1.87)		1.07(0.99–1.16)	
Diabetes Not Controlled vs. Non Diabetes	1.16(1.04–1.29)	0.0366	1.42(1.02–1.98)	0.1922	1.14(1.00–1.29)	0.1693
Diabetes Controlled vs. Non Diabetes	1.14(1.03–1.27)		1.27(0.83–1.94)		1.13(1.00–1.27)	
Pre-Diabetes vs. Non Diabetes	1.07(0.98–1.16)		1.17(0.93–1.45)		1.06(0.97–1.16)	
Obese vs. Normal Weight	1.02(0.94–1.10)	0.8907	0.93(0.74–1.16)	0.7083	1.03(0.94–1.14)	0.7690
Overweight vs. Normal Weight	1.02(0.94–1.11)		1.02(0.81–1.27)		1.03(0.93–1.15)	

6924 respondents were included in the model for total and severe periodontitis; 6061 respondents were included in the model for non-severe periodontitis. For non-severe periodontitis, severe periodontitis cases were excluded from the denominator.



**Table 3.**

Gender Stratified Prevalence Ratios for Periodontitis by Socio-demographic, Smoking and Co-morbid Conditions: NHANES 2009–2012

Effect	Total periodontitis (N=6924)		Severe Periodontitis (N=6924)		Non-Severe Periodontitis (N=6061)	
	Male (N=3458)	Female(N=3466)	Male(N=3458)	Female(N=3466)	Male(N=2836)	Female(N=3225)
	PR (CI)	PR (CI)	PR (CI)	PR (CI)	PR (CI)	PR (CI)
Age 65+ vs. Age 30–44	2.07(1.76–2.43)	3.15(2.63–3.77)	2.62(1.95–3.53)	2.71(1.23–5.94)	2.26(1.85–2.75)	3.44(2.83–4.17)
Age 55–64 vs. Age 30–44	1.82(1.64–2.02)	2.34(1.97–2.79)	2.95(2.18–3.99)	2.65(1.28–5.48)	1.91(1.71–2.13)	2.47(2.06–2.95)
Age 45–54 vs. Age 30–44	1.54(1.29–1.85)	1.77(1.47–2.14)	2.28(1.68–3.10)	2.11(1.24–3.57)	1.57(1.25–1.97)	1.82(1.50–2.20)
NH Hispanics vs. NH Whites	1.33(1.22–1.45)	1.45(1.25–1.68)	1.51(1.14–2.00)	1.74(1.25–2.42)	1.40(1.26–1.56)	1.47(1.25–1.72)
NH Blacks vs. NH Whites	1.30(1.19–1.42)	1.39(1.17–1.66)	1.72(1.32–2.26)	2.15(1.36–3.42)	1.32(1.18–1.49)	1.37(1.14–1.65)
Others vs. NH Whites	1.19(1.04–1.36)	1.55(1.28–1.87)	1.89(1.27–2.83)	1.21(0.64–2.30)	1.17(0.99–1.38)	1.61(1.31–1.97)
<High School vs. > High School	1.29(1.17–1.43)	1.29(1.09–1.52)	1.65(1.19–2.29)	1.60(1.18–2.16)	1.30(1.14–1.48)	1.28(1.07–1.53)
High School vs.>High School	1.22(1.11–1.34)	1.18(1.03–1.35)	1.64(1.19–2.26)	1.18(0.75–1.87)	1.21(1.07–1.38)	1.19(1.02–1.39)
Missing FPL vs. 400% FPL	1.18(0.99–1.42)	1.43(1.17–1.75)	1.75(1.01–3.05)	1.69(0.83–3.46)	1.14(0.92–1.41)	1.45(1.16–1.81)
Less than 100% FPL vs. 400% FPL	1.32(1.15–1.51)	1.58(1.29–1.92)	1.70(1.05–2.74)	1.93(0.90–4.14)	1.34(1.15–1.56)	1.60(1.29–1.97)
100–199% FPL vs. 400% FPL	1.24(1.12–1.36)	1.54(1.27–1.88)	1.77(1.08–2.91)	2.11(1.06–4.20)	1.23(1.12–1.36)	1.55(1.26–1.91)
200–399% FPL vs. 400% FPL	1.14(1.02–1.28)	1.42(1.17–1.72)	1.30(0.87–1.92)	1.47(0.67–3.24)	1.14(1.00–1.31)	1.45(1.18–1.79)
Married vs. Never Married	1.06(0.93–1.20)	0.84(0.72–0.97)	1.06(0.72–1.55)	1.23(0.78–1.93)	1.05(0.90–1.24)	0.80(0.68–0.95)
Divorced vs. Never Married	1.20(1.04–1.37)	0.97(0.81–1.18)	1.45(0.90–2.33)	1.48(0.83–2.61)	1.15(0.96–1.38)	0.92(0.76–1.13)
Widowed vs. Never Married	0.92(0.72–1.17)	0.80(0.62–1.04)	1.08(0.57–2.05)	1.29(0.70–2.35)	0.86(0.66–1.12)	0.76(0.57–1.01)
Living with Partner vs. Never Married	1.21(1.00–1.45)	0.84(0.68–1.04)	1.16(0.78–1.73)	1.43(0.77–2.66)	1.24(0.99–1.55)	0.80(0.62–1.03)
Current Smoker vs. Non Smoker	1.50(1.37–1.63)	1.61(1.45–1.80)	2.33(1.73–3.14)	2.97(1.87–4.70)	1.54(1.39–1.71)	1.59(1.41–1.80)
Former Smoker vs. Non Smoker	1.11(1.02–1.21)	1.07(0.93–1.23)	1.45(1.02–2.06)	1.19(0.77–1.84)	1.09(0.98–1.21)	1.05(0.91–1.22)
Diabetes Not Controlled vs. Non Diabetes	1.23(1.09–1.40)	1.04(0.82–1.33)	1.41(1.01–1.96)	1.61(0.90–2.88)	1.25(1.07–1.46)	1.00(0.75–1.32)
Diabetes Controlled vs. Non Diabetes	1.12(1.00–1.26)	1.17(0.96–1.43)	1.17(0.70–1.95)	1.58(0.83–2.99)	1.12(0.96–1.31)	1.13(0.911.41)
Pre-Diabetes vs. Non Diabetes	1.06(0.96–1.16)	1.07(0.93–1.21)	1.16(0.92–1.46)	1.19(0.74–1.92)	1.05(0.94–1.17)	1.06(0.92–1.22)
Obese vs. Normal Weight	0.99(0.89–1.09)	1.06(0.92–1.22)	1.08(0.78–1.50)	0.65(0.46–0.93)	0.98(0.85–1.12)	1.10(0.94–1.29)

Effect	Total periodontitis (N=6924)		Severe Periodontitis (N=6924)		Non-Severe Periodontitis (N=6061)	
	Male (N=3458)	Female(N=3466)	Male(N=3458)	Female(N=3466)	Male(N=2836)	Female(N=3225)
	PR (CI)	PR (CI)	PR (CI)	PR (CI)	PR (CI)	PR (CI)
Overweight vs. Normal Weight	1.02(0.91–1.14)	1.02(0.87–1.19)	1.20(0.87–1.64)	0.67(0.44–1.01)	1.01(0.87–1.16)	1.04(0.88–1.24)

6924 respondents were included in the model for total and severe periodontitis; 6061 respondents were included in the model for non-severe periodontitis. For non-severe periodontitis, severe periodontitis cases were excluded from the denominator.

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