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Prevalence of Periodontitis in Adults in the United States: 2009 and 2010

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RESEARCH REPORTS
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Prevalence of Periodontitis in Adults in the United States: 2009 and 2010

ABSTRACT

This study estimated the prevalence, severity, and extent of periodontitis in the adult U.S. population, with data from the 2009 and 2010 National Health and Nutrition Examination Survey (NHANES) cycle. Estimates were derived from a sample of 3,742 adults aged 30 years and older, of the civilian non-institutionalized population, having 1 or more natural teeth. Attachment loss (AL) and probing depth (PD) were measured at 6 sites *per* tooth on all teeth (except the third molars). Over 47% of the sample, representing 64.7 million adults, had periodontitis, distributed as 8.7%, 30.0%, and 8.5% with mild, moderate, and severe periodontitis, respectively. For adults aged 65 years and older, 64% had either moderate or severe periodontitis. Eighty-six and 40.9% had 1 or more teeth with AL ≥ 3 mm and PD ≥ 4 mm, respectively. With respect to extent of disease, 56% and 18% of the adult population had 5% or more periodontal sites with ≥ 3 mm AL and ≥ 4 mm PD, respectively. Periodontitis was highest in men, Mexican Americans, adults with less than a high school education, adults below 100% Federal Poverty Levels (FPL), and current smokers. This survey has provided direct evidence for a high burden of periodontitis in the adult U.S. population.

KEY WORDS: NHANES, periodontal disease, periodontitis, epidemiology, surveillance, adults.

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INTRODUCTION

Periodontal disease is an important public health problem in the United States. National disease surveillance and health promotion activities include periodontal disease as part of Healthy People 2020 by focusing on monitoring the reduction of moderate and severe periodontitis in the adult U.S. population (Healthy People 2020).

Historically, several national probability surveys have assessed the periodontal status of the U.S. population. The earliest of these surveys [1960-1962 Health Examination Survey, and the 1971-1974 National Health and Nutrition Examination Survey (NHANES)] assessed periodontal status visually, while subsequent surveys (NIDCR Survey of Employed Adults and Seniors 1985-1986, NHANES III 1988-1994, and NHANES 1999-2004) have used probe measurements to assess pocket depth (PD) and gingival recession around teeth. These assessments have been made by various partial mouth periodontal examinations (PMPE) protocols (Brown *et al.*, 1996; Dye and Thornton-Evans, 2007). The PMPE protocols used by NHANES have evolved, from the collection of measurements from 2 randomly selected quadrants of the mouth for assessment of PD and attachment loss (AL) at 2 sites *per* tooth (mid-buccal and mesio-buccal sites) in NHANES III and NHANES 1999-2000, to the assessment of 3 sites (mid-buccal, mesio-buccal, and distal sites) in NHANES 2001-2004. Because periodontitis is not evenly distributed in the mouth, prevalence estimates from surveys using PMPE protocols underestimate disease in the population (Hunt, 1987; Kingman *et al*., 1988, 2008; Hunt and Fann, 1991), and this underestimation can be significant in NHANES (Eke *et al.*, 2010).

A strategic objective of the CDC Periodontal Disease Surveillance Initiative has been to further improve surveillance of periodontitis in the adult U.S. population (Eke and Genco, 2007; Eke *et al*., 2012a). Activities and findings from this surveillance initiative have provided the evidence and opportunity to advocate why a full-mouth periodontal examination should be utilized on NHANES, and, in particular, the need to establish "true" baseline data on the prevalence of periodontitis in the United States. This led to the inclusion of the full-mouth periodontal examination (FMPE) protocol, beginning in the

NHANES 2009-2010 survey cycle. This survey cycle is the first national probability sample to use the FMPE protocol, collecting probe measurements from 6 sites *per* tooth for all teeth (except third molars) in U.S. adults.

The aim of this study was to provide estimates on the prevalence, severity, and extent of periodontitis in the adult U.S. population from data collected during NHANES 2009-2010. Estimates were determined according to suggested standard case definitions for population-based surveillance of periodontitis (Page and Eke, 2007; Eke *et al.*, 2012b) to estimate the burden of periodontitis in the adult U.S. population.

MATERIALS & METHODS

Data from NHANES 2009-2010 were used for this study. NHANES is a stratified multistage probability sample of the civilian non-institutionalized population in the 50 states of the U.S. 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. Oral health data collection protocols were approved by the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS) Ethics Review Board (the IRB equivalent), and all survey participants completed written informed consent.

All periodontal examinations were conducted in a mobile examination center (MEC) by dental hygienists registered in at least one U.S. state. Gingival recession [= distance between the free gingival margin (FGM) and the cemento-enamel junction (CEJ)] and pocket depth (PD) (= distance from FGM to the bottom of the sulcus or periodontal pocket) were measured at 6 sites *per* 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™, Chicago, IL, USA) with 2-, 4-, 6-, 8-, 10-, and 12-mm 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 an NHANES oral health data management program that instantly calculated attachment loss (AL) as the difference between probing depth and recession. Bleeding from probing and the presence of dental furcations were not assessed.

In NHANES 2009-2010, only adults aged 30 yrs or older with 1 or more natural teeth and not having a health condition that required antibiotic prophylaxis before periodontal probing were eligible for the periodontal examination. In total, 5,037 adults aged 30 yrs and older participated in NHANES. Among these, 951 were excluded from the oral health assessment in the MEC, due to medical exclusions or incomplete examinations, while, of the 4,086 adults who were examined completely, 343 were identified as edentulous. Periodontal measurements were collected for the remaining 3,743 participants, representing a weighted population of approximately 137.1 million civilian non-institutionalized American adults 30 yrs of age and older.

Prevalence of periodontitis was reported by 2 approaches. First, prevalence was reported according to the suggested CDC-AAP case definitions for surveillance of periodontitis (Page and Eke, 2007; Eke *et al*., 2012b). *Severe periodontitis* was defined as the presence of 2 or more interproximal sites with ≥ 6 mm AL (not on the same tooth) and 1 or more interproximal site(s) with ≥ 5 mm PD. *Moderate periodontitis* was defined as 2 or more interproximal sites with ≥ 4 mm clinical AL (not on the same tooth) or 2 or more interproximal sites with PD ≥ 5 mm, also not on the same tooth. *Mild periodontitis* was defined as ≥ 2 interproximal sites with ≥ 3 mm AL and ≥ 2 interproximal sites with ≥ 4 mm PD (not on the same tooth) or 1 site with ≥ 5 mm. *Total periodontitis* was the sum of severe, moderate, and mild periodontitis. For comparison with other published studies, we also included definitions by Arbes *et al.* (2001) (1 or more sites with ≥ 3 mm AL and ≥ 4 mm PD) and the European Federation of Periodontology (EFP) (Tonetti and Claffey, 2005). Second, we reported percentage severity of PD and AL using measurements from all 6 sites. Severity was also reported as the mean and prevalence of AL and PD cut-points, ranging from 3 mm to 7 mm. Extent of disease was reported by severity of disease at 5, 10, and 30% of sites and teeth.

For all data analyses, data (with MEC examination weights) were analyzed with SAS-callable SUDAAN software (release 10.0; Research Triangle Institute, Research Triangle Park, NC, USA) to adjust for the effects of the sampling design, including the unequal probability of selection.

RESULTS

In 2009 through 2010, the total prevalence of periodontitis in adults aged 30 yrs and older was 47.2% (representing about 64.7 million adults aged 30 yrs and older) in the U.S. (Table 1). When the CDC-AAP case definitions were applied individually, the prevalence of mild, moderate, and severe periodontitis was 8.7%, 30.0%, and 8.5%, respectively. Total periodontitis ranged from 24.4% in adults 30 to 34 yrs old to 70.1% in adults aged 65 yrs and older. Standardized for age, the prevalence of periodontitis was significantly higher in males than in females, highest among Mexican Americans compared with all other racial and ethnic groups studied, highest among persons with lowest educational status, increased with increasing poverty levels, and highest among current smokers. Eighty-six percent of adults had ≥ 1 site with AL ≥ 3 mm, with adults aged 65 yrs and older having the highest prevalence (96.7%). Fifteen percent of adults had ≥ 1 site with AL ≥ 7 mm, with adults who had less than a high school education having the highest prevalence (28.7%) (Table 2). Nearly 41.0% of adults had ≥ 1 site with ≥ 4 mm PD, with Mexican American adults having the highest prevalence (67.3%) (Table 3). Among all adults, 56.4% had at least 5% of their probed sites recording an AL ≥ 3 mm, whereas 19.4% had at least 30% of their probed sites affected by AL ≥ 3 mm. For PD, 18.7% had at least 5% of their probed sites affected by PD ≥ 4 mm, whereas 4.1% had at least 30% affected by PD ≥ 4 mm. At the tooth level, 73.5% of adults had at least 5% of their teeth with an AL ≥ 3 mm, whereas 47.2% had at least 30% of their teeth affected by AL ≥ 3 mm. For PD, 32.0% had at least 5% of their teeth affected by PD ≥ 4 mm, whereas 13.6% had at least 30% of their teeth affected by PD ≥ 4 mm (Appendix Table 1). Prevalence estimates based on the EFP definitions are presented in Appendix Table 2.

The prevalence of AL severity from ≥ 3 mm to ≥ 7 mm generally increased with increasing age (Fig., a), while PD severity from ≥ 3 mm to ≥ 7 mm remained relatively steady across all

Table 1. Prevalence of Periodontitis by Selected Characteristics for Persons Aged 30 yrs and Older, United States, 2009-2010

	N	Weighted N in Millions	% Total PD	SE	% Total PD Age* Standardized	SE	% Severe PD	SE	% Moderate PD	SE	% Mild PD	SE	% PD based on Arbes *et al.*, 2001	SE
Total	3,743	137.1	47.2	2.1	47.7	1.9	8.5	0.9	30.0	1.6	8.7	0.8	40.9	1.7
NHANES III Protocol[1]	3,733	136.8	19.5	1.9	19.6	1.8	1.8	0.4	12.7	1.4	5.0	0.5	16.5	1.4
NHANES 2000-2004 Protocol[2]	3,733	136.8	27.1	2.0	27.3	1.9	3.2	0.6	17.6	1.4	6.3	0.4	20.3	1.5
Age groups (yrs)														
30-34	435	16.7	24.4	2.7	St*		1.9	0.6	13.0	1.7	9.4	2.0	29.6	3.1
35-49	1,352	54.0	36.6	1.6	St*		6.7	0.8	19.4	1.7	10.4	1.3	35.5	1.7
50-64	1,128	43.4	57.2	2.6	St*		11.7	1.6	37.7	2.5	7.9	1.1	47.5	3.2
65+	828	22.9	70.1	3.0	St*		11.2	2.2	53.0	2.3	5.9	1.2	49.3	2.8
Gender														
Male	1,872	67.5	56.4	2.1	56.8	1.9	12.6	1.3	33.8	1.4	10.0	1.2	50.8	1.7
Female	1,871	69.6	38.4	2.4	38.8	2.2	4.5	0.7	26.4	2.2	7.5	0.8	31.3	1.7
Race/Ethnic[†]														
Mexican American	673	10.9	66.7	2.3	70.4	1.8	17.3	2.4	35.1	2.1	14.3	2.1	67.3	2.7
Non-Hispanic White	1,792	95.1	42.6	3.0	41.5	2.6	6.3	1.1	28.5	2.3	7.8	0.9	35.4	1.9
Non-Hispanic Black	673	15.0	58.6	3.1	59.7	3.0	13.2	1.8	33.6	2.1	11.8	1.3	55.4	2.4
Education														
< High school	1,030	23.8	66.9	2.4	66.7	2.3	17.3	2.1	40.6	2.6	9.0	1.4	60.3	2.1
High school	815	29.6	53.5	3.2	53.6	3.0	9.8	1.6	34.2	2.2	9.5	1.1	45.9	3.2
> High school	1,889	83.3	39.3	2.3	40.5	2.2	5.5	1.0	25.4	1.8	8.4	1.1	33.5	1.6
Poverty Level														
< 100% FPL	625	13.5	65.4	2.5	67.6	2.9	16.3	2.2	37.8	3.9	11.3	2.4	62.6	2.1
100-199% FPL	901	22.7	57.4	3.0	59.3	3.0	14.1	1.8	32.9	2.2	10.4	1.1	53.7	2.9
200-499% FPL	905	37.7	50.2	2.5	49.7	2.6	7.9	1.3	34.4	2.3	7.9	1.0	40.1	2.2
>= 400% FPL	960	52.4	35.4	3.0	35.2	2.3	4.1	0.9	23.5	2.0	7.9	1.4	30.1	2.3
Marital status														
Married	2,196	88.5	44.2	2.2	44.3	2.1	7.2	0.9	28.6	1.7	8.4	0.8	37.6	2.2
Widowed	292	7.6	62.2	4.5	44.1	6.9	10.4	2.2	45.1	4.0	6.7	1.3	43.9	4.4
Divorced	472	16.0	49.4	2.8	49.6	2.9	12.1	2.1	28.2	2.5	9.1	2.1	47.6	2.7
Separated	145	3.4	60.9	5.9	65.5	6.8	15.7	4.0	34.1	5.9	11.2	3.9	57.0	5.8
Never married	390	13.0	45.7	2.9	56.2	2.8	6.3	1.5	28.6	2.1	10.8	1.8	40.2	3.5
Living with partner	245	8.1	57.6	4.2	60.4	4.5	14.1	2.4	34.5	4.9	9.0	2.2	55.7	4.3
Smoking status														
Current smoker	728	23.2	64.2	2.6	68.7	2.6	17.7	2.4	36.5	2.1	10.0	1.3	59.8	3.1
Former smoker	957	35.7	52.5	3.1	46.5	2.6	9.0	1.3	35.6	3.1	8.0	1.1	43.5	2.7
Non-smoker	2,058	78.1	39.8	2.1	41.4	2.0	5.4	0.9	25.6	1.4	8.7	1.0	34.1	2.1

Source: CDC/NCHS, National Health and Nutrition Examination Survey, 2009-10. AL = Attachment loss; PD = pocket depth.

*Standardized to age distribution of the 2000 U.S. population. Mean number of total teeth was 24 (range, 1 -28), distributed as 26.5 for age group 30-34, 25.5 for age group 35-49, 23.2 for age group 50-64, and 20.6 for age group 65+. Six individuals with only 1 tooth were categorized as not having periodontitis according to the CDC-AAP case definitions because of the requirement for measures from more than 1 tooth.

[†]Other race and ethnic groups are included in the total but not shown separately. Race and ethnicity were self-reported and, for our analysis, were reported in 3 groups, for which statistical reliability was adequate: Mexican-Americans, non-Hispanic black, and non-Hispanic white.

[1]Prevalence estimates based on the PMPE protocols used in NHANES III and 1999-2000 of using only measurements of PD and AL from 2 fixed sites *per* tooth (mid-buccal and mesio-buccal sites) from all teeth in 2 randomly selected quadrants of the mouth.

[2]Prevalence estimates based on the PMPE protocol used in NHANES 2001–04 using only measurements of PD and AL from 3 fixed sites *per* tooth (mid-buccal, mesio-buccal, and distal sites) from all teeth in 2 randomly selected quadrants of the mouth.

Poverty status or percentage of poverty levels based on family income, family size, and the number of children in the family and for families with two or fewer adults, on the age of the adults in the family. The poverty level is based on definitions originally developed by the Social Security Administration and includes a set of income thresholds that vary by family size and composition. Families or individuals with income below their appropriate thresholds are classified as below the poverty level. These thresholds are updated annually by the US Census Bureau. Additional information can be located at: http://aspe.hhs.gov/poverty/11poverty.shtml.

Education was classified as less than high school, high school graduate or General Education Development high school equivalency test (GED), and greater than high school.

Smoking status was constructed from responses to 2 questions: (1) Have you smoked at least 100 cigarettes in life? (SMQ020), and (2) Do you now smoke cigarettes? (SMQ040). Persons who reported smoking every day or some days and who had smoked at least 100 cigarettes were categorized as current smokers; persons who reported having smoked more than 100 cigarettes but were currently not smoking were categorized as former smokers; and persons who reported never having smoked were categorized as non-smokers.

Table 2. Prevalence of Different Cut-off Values of Attachment Loss (AL) and Mean by Selected Characteristics for Persons Aged 30 yrs and Older, United States, 2009-2010

	Percentage (%)											
	AL > = 3 mm	SE	AL > = 4 mm	SE	AL > = 5 mm	SE	AL > = 6 mm	SE	AL > = 7 mm	SE	Mean of AL (mm)	SE
Total	85.9	1.3	63.3	1.7	43.4	1.7	25.5	1.3	15.2	1.0	1.59	0.05
Age groups (yrs)												
30-34	64.1	2.1	32.4	3.1	16.9	2.4	9.5	1.5	3.9	1.1	1.05	0.03
35-49	83.1	1.5	53.5	2.7	32.9	1.9	16.2	1.0	9.8	0.6	1.34	0.04
50-64	92.0	1.8	75.5	2.0	54.2	2.2	32.8	2.3	20.9	1.7	1.85	0.07
65+	96.7	0.9	85.9	2.4	67.1	2.6	45.1	3.0	25.6	2.8	2.10	0.11
Gender												
Male	90.6	1.0	71.5	1.6	52.0	1.7	31.8	1.8	20.1	1.3	1.83	0.07
Female	81.3	1.9	55.3	2.5	35.0	2.2	19.3	1.4	10.5	0.9	1.37	0.05
Race/Ethnic[†]												
Non-Hispanic White	84.7	1.8	60.8	2.4	39.5	2.4	21.5	1.8	11.8	1.3	1.51	0.07
Non-Hispanic Black	86.0	1.9	66.3	2.5	49.6	2.7	35.7	3.0	23.8	2.1	1.84	0.09
Mexican American	92.6	1.1	73.2	2.1	56.4	2.9	37.9	2.7	25.1	2.3	1.89	0.08
Education												
< High school	90.8	1.5	77.0	2.2	59.2	2.5	41.3	2.0	28.7	1.8	2.18	0.08
High school	87.8	1.7	67.6	2.6	47.5	2.3	30.9	2.0	20.7	1.5	1.76	0.08
> High school	83.7	1.4	57.7	2.0	37.3	1.8	19.0	1.6	9.5	1.1	1.37	0.05
Poverty Level												
< 100% FPL	90.8	1.8	73.1	2.3	54.5	2.1	39.6	2.0	26.7	1.9	2.14	0.07
100-199% FPL	89.5	1.4	69.0	2.6	51.3	2.3	34.0	1.5	22.6	1.7	1.91	0.09
200-499% FPL	85.1	2.1	66.1	2.4	45.7	2.1	27.4	2.4	15.4	1.7	1.61	0.07
>= 400% FPL	83.7	1.6	56.1	2.3	34.7	2.6	15.9	1.4	8.3	0.9	1.31	0.05
Marital status												
Married	85.2	1.3	60.4	2.0	40.5	1.7	23.1	1.3	13.7	1.0	1.50	0.04
Widowed	93.1	1.9	80.3	2.1	62.2	3.5	41.8	3.0	23.8	2.9	2.02	0.15
Divorced	90.3	1.8	70.9	2.8	49.1	3.9	30.0	2.5	20.2	1.9	1.78	0.09
Separated	91.2	2.6	73.5	4.3	56.3	6.6	33.9	4.7	19.7	3.3	1.85	0.10
Never married	81.6	2.4	58.5	3.5	35.7	4.7	18.5	3.2	11.2	1.7	1.53	0.10
Living with partner	81.5	4.1	65.7	5.6	51.9	4.9	32.9	3.4	19.2	2.8	1.79	0.10
Smoking status												
Current smoker	90.6	1.3	72.6	2.2	54.2	2.6	39.6	2.2	26.5	2.3	2.17	0.09
Former smoker	87.9	1.6	68.8	3.0	49.2	3.3	29.6	3.3	16.1	1.9	1.70	0.10
Non-smoker	83.5	1.4	58.0	1.8	37.5	1.4	19.4	1.1	11.5	0.8	1.37	0.04

Mean of AL is the average attachment loss in millimeters of all measured sites in all study participants.

age groups (Fig., b). Prevalence of total and moderate periodontitis increased with increasing age among all adults, while the prevalence of mild and severe periodontitis remained relatively steady at less than 15% across all age groups (Fig., c).

DISCUSSION

The FMPE protocol used in NHANES 2009-2010 collected optimal surveillance measurements for assessing the burden of periodontitis in the U.S. population. Because this is the first use of a FMPE protocol in NHANES, the findings presented in this report have provided the most direct evidence for estimating the true burden of periodontitis in the adult U.S. population when compared with results from previous national surveys. Analysis of the overall data collected from this survey demonstrates a high burden of periodontitis and disease disparity within sociodemographic groups of the adult U.S. population.

Using the CDC-AAP suggested case definitions for surveillance of periodontitis, we determined that about 47% of U.S. dentate adults aged 30 yrs and older (representing approximately 65 million adults) have periodontitis, with 38% of the adult population 30 yrs and older and 64% of adults 65 yrs and older having either severe or moderate periodontitis. Overall, these estimates were much lower than those reported from European populations (Bourgeois *et al.*, 2007; Holtfreter *et al.*, 2010). Compared with earlier findings, the underestimation of periodontitis in the U.S. population has now become clearer. For U.S. adults aged 65 yrs and older, the earlier estimates for moderate or severe periodontitis were 26% and 17% in NHANES III and NHANES 1999-2004, respectively, based on the PMPE

Table 3. Prevalence of Different Cut-off Values of Pocket Depth (PD) and Mean by Selected Characteristics for Persons Aged 30 yrs and Older, United States, 2009-2010

	Percentage (%)											
	PD > = 3 mm	SE	PD > = 4 mm	SE	PD > = 5 mm	SE	PD > = 6 mm	SE	PD > = 7 mm	SE	Mean of PD (mm)	SE
Total	76.1	1.8	40.9	1.7	18.7	1.7	11.0	1.3	4.2	0.7	1.67	0.04
Age groups (yrs)												
30-34	64.7	3.6	29.6	3.1	11.7	1.7	7.1	1.7	2.6	1.0	1.50	0.04
35-49	72.0	2.1	35.5	1.7	16.1	1.7	9.5	1.4	3.7	0.6	1.62	0.04
50-64	81.3	2.7	47.5	3.2	22.4	2.6	13.3	2.0	5.5	1.3	1.76	0.05
65+	84.5	2.1	49.3	2.8	22.9	3.0	13.0	2.1	4.2	0.9	1.76	0.05
Gender												
Male	83.6	2.3	50.8	1.7	26.1	2.2	15.7	1.9	6.6	1.0	1.84	0.05
Female	68.9	1.9	31.3	1.7	11.5	1.4	6.4	1.0	2.0	0.4	1.51	0.03
Race/Ethnic†												
Non-Hispanic White	72.6	2.3	35.4	1.9	14.2	2.0	8.1	1.4	2.6	0.6	1.59	0.04
Non-Hispanic Black	84.4	2.2	55.4	2.4	29.8	3.6	17.8	3.0	7.6	1.8	1.88	0.08
Mexican American	90.5	1.3	67.3	2.7	40.5	3.7	26.5	3.2	15.0	2.9	2.09	0.06
Education												
< High school	84.4	2.3	60.3	2.1	33.1	3.3	19.6	2.8	7.8	1.8	1.98	0.06
High school	79.4	3.8	45.9	3.3	22.1	2.1	13.9	2.1	5.6	1.1	1.72	0.06
> High school	72.5	1.7	33.5	1.6	13.4	1.9	7.5	1.2	2.7	0.6	1.57	0.03
Poverty Level												
< 100% FPL	87.9	1.4	62.6	2.1	33.4	3.1	18.8	2.8	8.5	2.3	2.03	0.05
100-199% FPL	81.2	2.4	53.7	2.9	26.3	2.9	16.8	2.7	6.5	1.3	1.87	0.05
200-499% FPL	77.0	2.1	40.1	2.2	19.2	2.3	12.2	1.8	4.5	0.9	1.65	0.04
>= 400% FPL	69.2	2.8	30.1	2.3	10.3	1.4	4.8	0.8	1.9	0.5	1.51	0.04
Marital status												
Married	74.6	1.9	37.6	2.2	15.7	1.7	8.8	1.2	3.4	0.5	1.62	0.04
Widowed	77.9	3.6	43.9	4.4	21.6	3.3	15.0	2.4	3.8	1.4	1.71	0.07
Divorced	78.0	2.7	47.6	2.7	22.4	2.1	13.8	2.4	6.0	1.5	1.75	0.04
Separated	85.5	6.2	57.0	5.8	33.9	6.8	23.2	4.2	10.8	2.5	1.93	0.10
Never married	77.4	3.3	40.2	3.5	17.6	2.6	9.8	2.1	4.4	1.4	1.71	0.05
Living with partner	82.5	3.6	55.7	4.3	37.0	4.7	22.8	4.0	7.3	2.3	1.91	0.07
Smoking status												
Current smoker	86.0	1.9	59.8	3.1	34.1	3.4	20.7	3.5	7.5	1.6	2.00	0.07
Former smoker	79.5	2.0	43.5	2.7	17.8	2.5	11.0	1.8	4.7	0.8	1.67	0.04
Non-smoker	71.7	2.3	34.1	2.1	14.5	1.6	8.1	1.1	3.0	0.7	1.57	0.04

Mean of PD is the average pocket depth in millimeters of all measured sites in all study participants.

(USDHHS, 2007), compared with our current finding of 64% using the FMPE. Among adults aged 30 yrs and older, we report a much higher prevalence of AL ≥ 3 mm and PD ≥ 4 mm of 85.9% and 40.9%, respectively, compared with 53.1% and 23.1% reported from NHANES III (Albandar *et al*., 1999). When we applied the NHANES III and NHANES 1999-2004 PMPE protocols to this survey dataset, we determined a total prevalence of 19.5% and 27.1% from both protocols, respectively, compared with 47% from the FMPE protocol, representing a negative relative bias of 59% and 43% (inflation factors of 2.45 and 1.74), respectively. The high levels of bias and underestimation of prevalence from previous PMPE protocols are consistent with findings from our pilot study (Eke *et al.*, 2010) and other reports (Kingman and Albandar, 2002; Susin, Kingman, and Albandar, 2005; Beck *et al*., 2006), and serve as the basis for concern that a full-mouth periodontal examination should be utilized intermittently in NHANES to generate valid correction factors for future surveys based on PMPE protocols.

Our findings reaffirm disparities in the burden of periodontitis by socio-demographic segments of the adult U.S. population. After adjustment for the effect of age, total periodontitis was significantly higher in men than in women. Among racial and ethnic groups, Mexican Americans had the highest prevalence of periodontitis, closely followed by Non-Hispanic blacks. The prevalence of periodontitis increased with increasing poverty levels and lower education, with about 67% of persons less than 100% of FPL having periodontitis. Overall, the highest prevalence of periodontitis was seen among Mexican Americans, adults with lowest education, adults less than 100% of FPL, and current smokers. These socio-demographic patterns remain consistent with findings from previous NHANES (Albandar *et al*., 1999), although more detailed multivariable analyses controlling for factors

associated with prevalence of periodontitis will be required to confirm these findings.

The increase in the prevalence of periodontitis with increasing age appears to be influenced mostly by the increasing prevalence of moderate periodontitis, probably due to cases deteriorating from mild periodontitis with increasing age. Prevalence of severe periodontitis appears to have remained consistent at less than 15% across all age groups. This may be due to loss of teeth associated with severe disease, or there may be other unique features of those who have severe periodontitis. Severity of PD did not increase with age, while severity of AL increased with age, suggesting that AL may be a more relevant measure of periodontitis in population studies.

The strength of this report comes from the unprecedented use of data from a FMPE protocol, which results in better representation of persons, teeth, and sites assessed, and the use of conservative case definitions for periodontitis, which are more likely to capture true disease. Collectively, these factors ensure minimal misclassification of disease status in the source population than in previous NHANES and present a superior dataset for etiologic research. However, several factors may still underestimate the prevalence of disease. Notably, conservative case definitions not using measurements from all 6 sites may underestimate disease, *e.g.*, the CDC-AAP suggested case definitions use only measures from interproximal sites and detect a prevalence of 47.2% compared with a prevalence of 56% when measures from all 6 sites (including the mid-buccal and mid-lingual sites) are used. Also, inflammation and furcation status were not assessed, which can provide additional information regarding disease status. Our prevalence estimates included only gingivitis that may accompany the cases detected, and did not include individuals with only gingivitis; thus, the prevalence of cases that includes all forms of periodontal disease would likely be even higher. Also, medical exclusion and the non-sampling of institutionalized persons in nursing homes may have introduced some selection bias. Finally, the survey did not collect data from third molars, which may further underestimate periodontitis.

We consider the estimates derived in this report to be interim national estimates, because of possible under-sampling of certain subsets of our population, even though this NHANES 2-year dataset is considered a nationally representative sample. A minimum of 4, possibly 6, yrs of data may be required to affirm national estimates on all sub-groups. Ongoing NHANES for the 2011-2014 data cycle will over-sample the Asian-American population to provide more stable estimates for this sub-group and to provide a sufficient pool for the assessment of trends. In conclusion, the higher burden of periodontitis in the adult U.S. population and the prevailing disparities among socio-demographic segments detected from this survey, coupled with the potential economic cost for prevention and treatment, suggest periodontitis as an important dental public health problem, especially among our aging population.

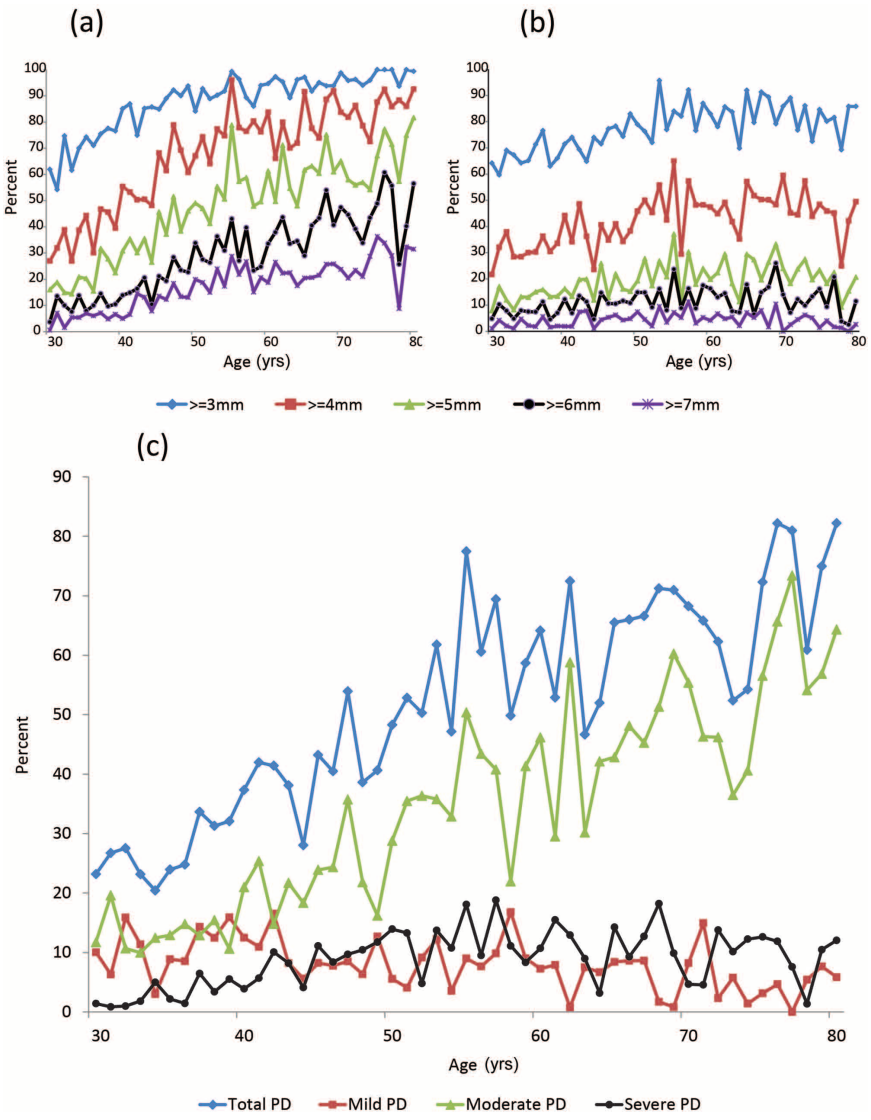

Figure. Prevalence by age. **(a)** The percentage prevalence of different cut-off values (3 mm, 4 mm, 5 mm, 6 mm, 7 mm) for AL by age. **(b)** The percentage prevalence of different cut-off values (3 mm, 4 mm, 5 mm, 6 mm, 7 mm) for PD by age. **(c)** The percentage of total periodontitis, severe periodontitis, moderate periodontitis, and mild periodontitis by age.

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