

Update on Prevalence of Periodontitis in Adults in the United States: NHANES 2009 to 2012

Paul I. Eke,* Bruce A. Dye,† Liang Wei,‡ Gary D. Slade,§ Gina O. Thornton-Evans,|| Wenche S. Borgnakke,¶ George W. Taylor,# Roy C. Page,** James D. Beck,§ and Robert J. Genco††

Background: This report describes prevalence, severity, and extent of periodontitis in the US adult population using combined data from the 2009 to 2010 and 2011 to 2012 cycles of the National Health and Nutrition Examination Survey (NHANES).

Methods: Estimates were derived for dentate adults, aged ≥ 30 years, from the US civilian non-institutionalized population. Periodontitis was defined by combinations of clinical attachment loss (AL) and periodontal probing depth (PD) from six sites per tooth on all teeth, except third molars, using standard surveillance case definitions. For the first time in NHANES history, sufficient numbers of non-Hispanic Asians were sampled in 2011 to 2012 to provide reliable estimates of their periodontitis prevalence.

Results: In 2009 to 2012, 46% of US adults, representing 64.7 million people, had periodontitis, with 8.9% having severe periodontitis. Overall, 3.8% of all periodontal sites (10.6% of all teeth) had PD ≥ 4 mm, and 19.3% of sites (37.4% teeth) had AL ≥ 3 mm. Periodontitis prevalence was positively associated with increasing age and was higher among males. Periodontitis prevalence was highest in Hispanics (63.5%) and non-Hispanic blacks (59.1%), followed by non-Hispanic Asian Americans (50.0%), and lowest in non-Hispanic whites (40.8%). Prevalence varied two-fold between the lowest and highest levels of socioeconomic status, whether defined by poverty or education.

Conclusions: This study confirms a high prevalence of periodontitis in US adults aged ≥ 30 years, with almost fifty-percent affected. The prevalence was greater in non-Hispanic Asians than non-Hispanic whites, although lower than other minorities. The distribution provides valuable information for population-based action to prevent or manage periodontitis in US adults. *J Periodontol* 2015;86:611-622.

KEY WORDS

Dental health surveys; epidemiology; periodontal diseases; periodontitis; population surveillance; United States.

* Division of Population Health, Centers for Disease Control and Prevention (CDC), Atlanta, GA.

† Division of Health and Nutrition Examination Surveys, CDC, Hyattsville, MD.

‡ DB Consulting Group, Atlanta, GA.

§ Department of Dental Ecology, University of North Carolina School of Dentistry, Chapel Hill, NC.

|| Division of Oral Health, CDC, Atlanta, GA.

¶ Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, MI.

Department of Preventive and Restorative Dental Sciences, University of California School of Dentistry, San Francisco, CA.

** Department of Periodontics, University of Washington School of Dentistry, Seattle, WA.

†† Department of Oral Biology, State University of New York School of Dental Medicine, Buffalo, NY.

Periodontal disease is highly prevalent among adults in the United States and is an important dental public health problem.¹ The monitoring and reduction of moderate and severe periodontitis in the adult US population through national disease surveillance and health promotion activities is part of the Healthy People 2020 national health objective² and is an important strategic objective of the Centers for Disease Control and Prevention (CDC).^{3,4}

The burden of periodontitis in the adult US population is currently assessed through the National Health and Nutrition Examination Survey (NHANES). Since 1999, NHANES has been a continuous, annual survey capable of producing national estimates on selected health characteristics within 2-year periods. However, the protocol for assessing periodontitis has varied. Beginning in 2009 and ending in 2014, NHANES will have applied a full-mouth periodontal examination (FMPE) protocol to collect probing measurements from six sites per tooth for all teeth (except third molars).¹ The FMPE optimizes clinical measurements for surveillance of periodontitis and represents better accuracy in detecting cases of periodontitis compared with estimates derived from partial-mouth periodontal examination (PMPE) protocols used in previous NHANES surveys, such as 1999 to 2004 or 1988 to 1994.⁵⁻⁹ Also, the FMPE protocol optimizes the use of standard case definitions for surveillance of periodontitis, minimizes misclassification of periodontitis cases, and can be applied to various case definitions owing to the comprehensive measurements.¹⁰⁻¹⁴ With use of the FMPE protocol, it was estimated in 2009 to 2010 that 47% of US dentate adults aged ≥ 30 years (representing ≈ 65 million adults) had periodontitis, with 38% of the adult population aged ≥ 30 years and 64% of adults ≥ 65 years having either severe or moderate periodontitis.¹ These initial findings revealed a much higher burden of periodontitis in US adults than previously reported.¹

In this report, the authors provide updated prevalence estimates using combined data from the NHANES survey periods 2009 to 2010 and 2011 to 2012. Based on a larger sample size, the 4-year combined data provide more stable estimates, especially for smaller subpopulations, than the individual data sets. Importantly, the 2011 to 2012 data provide the first occasion at which NHANES data generated reliable estimates of periodontitis among non-Hispanic Asian Americans.

MATERIALS AND METHODS

The present study uses data from NHANES 2009 to 2012.¹⁵ NHANES is a stratified multistage probability sample of the civilian non-institutionalized pop-

ulation in the United States and the District of Columbia. NHANES oversamples different subpopulations to improve estimate accuracy, and in 2011 to 2012, non-Hispanic Asian Americans were oversampled.¹⁶ Oral health data collection protocols¹⁷ were approved by the CDC/National Center for Health Statistics (NCHS) Ethics Review Board (an institutional review board equivalent), Atlanta, Georgia, and all survey participants provided written informed consent.

All periodontal examinations were conducted in a mobile examination center (MEC). All MEC dental examiners were trained and calibrated by the survey's reference examiner (BD).¹⁸ The latter undertook both the initial training and calibration, but also visited each examiner in the field and replicated 25 to 30 periodontal examinations each time. Dye et al.¹⁸ have described in detail the oral health component, including its quality assurance for the 2009 to 2010 examinations, providing interexaminer statistics expressed as percent agreement, κ statistics, and intraclass correlation coefficients. For the CDC/American Academy of Periodontology (AAP) moderate and severe periodontitis case definitions taken together, the κ scores were 0.70 and 0.71 for the two examiners, whose agreement rates with the reference examiner were 87.5% and 85.7%, respectively. The intraclass correlation coefficients for mean AL were ≥ 0.80 for both examiners. Hence, the level of data quality is acceptable.¹⁸ Results from such data reliability analyses are not currently available for the data collected in 2011 to 2012.

The same examiners made two measurements at each periodontal site: gingival recession (GR) (distance between the free gingival margin [FGM] and the cemento-enamel junction [CEJ]) and probing depth (PD) (distance from FGM to the bottom of the sulcus or periodontal pocket). GR was recorded as a negative value when the FGM was positioned apically to the CEJ and positive when positioned coronally. Measurements were made at six sites per tooth (mesio-, mid-, and disto-buccal; mesio-, mid-, and disto-lingual) for all teeth, excluding third molars. A periodontal probe with 2- to 4-, 6- to 8-, and 10- to 12-mm graduations^{††} was positioned parallel to the long axis of the tooth at each site, and measurements were rounded to the lower whole millimeter. Data were recorded directly into an NHANES oral health data management program that instantly calculated clinical attachment loss (AL) as the difference between PD and recession (PD – REC). Bleeding on probing (BOP) and the presence of dental furcations were not assessed. The periodontal protocol for

†† PCP 2, Hu-Friedy, Chicago, IL.

NHANES 2009 to 2012 was restricted to adults aged ≥ 30 years with ≥ 1 natural teeth and no health condition requiring antibiotic prophylaxis before periodontal probing. A total of 9,402 adults aged ≥ 30 years participated in NHANES MEC examinations. Among these, 1,631 were excluded from the oral health assessment for medical conditions or for other reasons did not complete their oral examination, whereas 7,771 persons underwent complete oral examinations, including 705 who were edentulous. Periodontal measurements were collected for the remaining 7,066 participants (3,515 males and 3,551 females, aged 30 to 80 years; mean age: 51 years), representing a weighted population of approximately 141 million civilian non-institutionalized American adults aged ≥ 30 years.

Prevalence of periodontitis was calculated using three approaches. 1) Prevalence was reported using the suggested CDC/AAP case definitions for surveillance of periodontitis.^{19,20} Severe periodontitis was defined as having ≥ 2 interproximal sites with AL ≥ 6 mm (not on the same tooth) and ≥ 1 interproximal sites with PD ≥ 5 mm. 2) "Other" periodontitis comprised two lesser amounts of disease: moderate periodontitis, defined as ≥ 2 interproximal sites with AL ≥ 4 mm (not on the same tooth) or ≥ 2 interproximal sites with PD ≥ 5 mm, also not on the same tooth; and mild periodontitis, defined as ≥ 2 interproximal sites with AL ≥ 3 mm and ≥ 2 interproximal sites with PD ≥ 4 mm (not on the same tooth) or one site with PD ≥ 5 mm. These subgroups are not truly ordinal as the label suggests, because many of the "moderate" cases had insufficient PD to qualify as "mild," and therefore they have been combined with the label "other" periodontitis. 3) Total periodontitis was defined as the presence of either severe or "other" periodontitis.

For comparison with other national and international studies published, the authors also applied case definitions of the European Federation of Periodontology (EFP), using the AL categories for manifest (interpreted as equivalent-to-severe) and incipient (interpreted as equivalent-to-mild) periodontitis, although these case definitions were designed specifically to identify risk factors for periodontitis when supplemented with some measure of current inflammation in addition to the past tissue loss measured by AL.²¹ Second, the severity and extent of PD and AL are reported using measurements from all six sites per tooth. Severity was also reported as the mean and prevalence of AL and PD cut points ranging from 3 to 7 mm. Extent of disease was reported by specific PD and AL values at 5%, 10%, and 30% of sites and teeth, respectively.

Age and sex were used as collected by NHANES. For this report, age was stratified as 30 to 34, 35 to

49, 50 to 64, and ≥ 65 years old. Race/ethnicity was self-reported in four groups: 1) Hispanics (a combination of Mexican Americans and other Hispanics), 2) non-Hispanic Asian American, 3) non-Hispanic whites, and 4) non-Hispanic blacks. Marital status was reported as: married, widowed, divorced, separated, never married, or living with a partner. Education was classified as less than high school, high school graduate or General Education Development (GED) high school equivalency test, and more than high school. Smoking status was constructed from responses to two questions: 1) "Have you smoked at least 100 cigarettes in your entire life?"¹ and 2) "Do you now smoke cigarettes?"² Respondents who reported smoking every day or some days and had smoked ≥ 100 cigarettes were categorized as current smokers; respondents who reported currently not smoking but having smoked >100 cigarettes in the past were categorized as former smokers; and respondents who reported having smoked <100 cigarettes ever were categorized as non-smokers.

Poverty status was based on family income, family size, and the number of children in the family, and for families with ≤ 2 adults, on the age of the adults in the family. The poverty level was based on definitions originally developed by the Social Security Administration that include a set of income thresholds, which vary by family size and composition. Families or individuals with incomes below their appropriate thresholds were classified as below the poverty level according to the thresholds that are updated annually by the US Census Bureau.²²

Applying MEC examination weights, data were analyzed^{§§} while adjusting for the effects of the sampling design, including the unequal probability of selection.

RESULTS

Overall, 44.7% (SE: $\pm 2.4\%$) of adults aged ≥ 30 years in the United States had periodontitis during 2011 to 2012 (Table 1). This estimate was statistically consistent with the 47.2% (standard error [SE]: $\pm 2.1\%$) reported for NHANES 2009 to 2010 cycle. For the combined period of 2009 to 2012 (representing ≈ 141 million adults ≥ 30 years old), the prevalence of periodontitis was 45.9% (Table 1). The mean number of teeth per participant was 24 (range: 1 to 28). Sixteen participants with only one tooth were categorized as not having periodontitis as per the CDC/AAP case definitions because of the requirement for measures from >1 tooth. When the previously used NHANES III and NHANES 2001 to 2004 PMPE protocols were applied to the 2009 to 2012 NHANES

§§ SAS-callable SUDAAN software, v.10.0, Research Triangle Institute, Research Triangle Park, NC.

Table 1. Prevalence of Total Periodontitis Using NHANES Data by Selected Characteristics and Individual NHANES Cycles for Individuals Aged ≥30 Years in the United States, 2009 to 2010 and 2011 to 2012

Characteristics	NHANES 2009 to 2010			NHANES 2011 to 2012			NHANES 2009 to 2012 (Combined NHANES 2009 to 2010 and 2011 to 2012)		
	n	Weighted n (millions)*	Total Periodontitis (% ± SE)†	n	Weighted n (millions)	Total Periodontitis (% ± SE)	n	Weighted n (millions)	Total Periodontitis (% ± SE)
All (NHANES 2009 to 2012)	3,743	137.1	47.2 ± 2.1	3,323	144.8	44.7 ± 2.4	7,066	141.0	45.9 ± 1.6
NHANES III protocol§	3,733	136.8	19.5 ± 1.9	3,310	144.6	18.2 ± 1.1	7,043	140.7	18.8 ± 1.1
NHANES 2001 to 2004 protocol	3,733	136.8	27.1 ± 2.0	3,311	144.6	25.6 ± 1.3	7,044	140.7	26.3 ± 1.2
Age (mean: 24 teeth)									
30 to 34 years	435	16.7	24.4 ± 2.7	411	17.7	25.3 ± 2.6	846	17.2	24.8 ± 1.9
35 to 49 years	1,352	54.0	36.6 ± 1.6	1,143	54.0	37.8 ± 2.9	2,495	54.0	37.2 ± 1.7
50 to 64 years	1,128	43.4	57.2 ± 2.6	1,086	48.4	48.7 ± 3.5	2,214	45.9	52.7 ± 2.3
≥65 years	828	22.9	70.1 ± 3.0	683	24.7	66.0 ± 3.0	1,511	23.8	68.0 ± 2.2
Sex									
Males	1,872	67.5	56.4 ± 2.1	1,643	70.5	53.4 ± 2.4	3,515	69.0	54.9 ± 1.6
Females	1,871	69.6	38.4 ± 2.4	1,680	74.3	36.5 ± 2.6	3,551	72.0	37.4 ± 1.8
Race/ethnic group									
Hispanic	673	10.9	66.7 ± 2.3	355	11.1	60.4 ± 2.3	1,028	11.0	63.5 ± 1.7
Non-Hispanic Asian American††	N/A	N/A	N/A	478	7.6	50.0 ± 3.7	N/A	N/A	N/A
Non-Hispanic white	1,792	95.1	42.6 ± 3.0	1,226	98.8	39.0 ± 2.7	3,018	97.0	40.8 ± 2.1
Non-Hispanic black	673	15.0	58.6 ± 3.1	839	15.3	59.7 ± 3.2	1,512	15.1	59.1 ± 2.2
Education									
Less than high school	1,030	23.8	66.9 ± 2.4	754	22.3	67.1 ± 2.4	1,784	23.1	67.0 ± 1.7
High school/GED	815	29.6	53.5 ± 3.2	699	29.4	57.9 ± 2.9	1,514	29.5	55.7 ± 2.1
More than high school	1,889	83.3	39.3 ± 2.3	1,868	93.2	35.2 ± 2.2	3,757	88.3	37.2 ± 1.6

Table 1. (continued)

Prevalence of Total Periodontitis Using NHANES Data by Selected Characteristics and Individual NHANES Cycles for Individuals Aged ≥30 Years in the United States, 2009 to 2010 and 2011 to 2012

Characteristics	NHANES 2009 to 2010			NHANES 2011 to 2012			NHANES 2009 to 2012 (Combined NHANES 2009 to 2010 and 2011 to 2012)					
	n	Total Periodontitis		n	Total Periodontitis		n	Total Periodontitis				
		Weighted n (millions)*	Periodontitis (% ± SE)†		Age Standardized (% ± SE)‡	Weighted n (millions)		Periodontitis (% ± SE)†	Age Standardized (% ± SE)‡	Weighted n (millions)	Periodontitis (% ± SE)†	Age Standardized (% ± SE)‡
Income												
<100% FPL	625	13.5	65.4 ± 2.5	67.6 ± 2.9	632	17.4	59.8 ± 2.1	60.9 ± 2.0	1,257	15.5	62.2 ± 1.6	63.7 ± 1.6
100% to 199% FPL	901	22.7	57.4 ± 3.0	59.3 ± 3.0	782	27.1	56.6 ± 2.5	57.8 ± 2.7	1,683	24.9	57.0 ± 2.0	58.3 ± 2.0
200% to 499% FPL	905	37.7	50.2 ± 2.5	49.7 ± 2.6	755	37.4	46.2 ± 4.9	46.0 ± 4.3	1,660	37.6	48.2 ± 2.7	47.8 ± 2.5
≥400% FPL	960	52.4	35.4 ± 3.0	35.2 ± 2.3	888	54.3	30.7 ± 1.8	30.7 ± 1.5	1,848	53.4	33.0 ± 1.8	32.9 ± 1.4
Marital status												
Married	2,196	88.5	44.2 ± 2.2	44.3 ± 2.1	1,853	88.1	39.5 ± 2.3	39.9 ± 2.1	4,049	88.4	41.9 ± 1.7	42.1 ± 1.6
Widowed	292	7.6	62.2 ± 4.5	44.1 ± 6.9	233	7.0	60.2 ± 5.6	51.8 ± 7.2	525	7.3	61.3 ± 3.6	49.1 ± 5.5
Divorced	472	16	49.4 ± 2.8	49.6 ± 2.9	402	18.1	57.4 ± 4.5	55.3 ± 4.0	874	17.1	53.6 ± 2.7	52.6 ± 2.5
Separated	145	3.4	60.9 ± 5.9	65.5 ± 6.8	151	4.2	60.3 ± 7.9	65.9 ± 6.4	296	3.8	60.6 ± 5.1	65.0 ± 4.7
Never married	390	13	45.7 ± 2.9	56.2 ± 2.8	431	16.6	44.1 ± 3.7	49.1 ± 3.8	821	14.8	44.8 ± 2.5	51.9 ± 2.6
Living with partner	245	8.1	57.6 ± 4.2	60.4 ± 4.5	250	10.8	51.2 ± 5.2	55.6 ± 5.1	495	9.5	54.0 ± 3.5	58.4 ± 3.5
Smoking status												
Current smoker	728	23.2	64.2 ± 2.6	68.7 ± 2.6	610	25.9	68.7 ± 2.5	72.4 ± 2.2	1,338	24.6	66.6 ± 1.8	70.8 ± 1.6
Former smoker	957	35.7	52.5 ± 3.1	46.5 ± 2.6	812	38.3	45.0 ± 3.4	42.1 ± 2.8	1,769	37.1	48.7 ± 2.5	44.2 ± 2.0
Non-smoker	2,058	78.1	39.8 ± 2.1	41.4 ± 2.0	1,898	80.5	36.8 ± 2.1	38.3 ± 1.8	3,956	79.3	38.3 ± 1.5	39.8 ± 1.4

N/A = not applicable; GED = General Education Development high school equivalency test; FPL = federal poverty level.
 * Source population represented applying MEC weights.
 † Total periodontitis, sum of prevalence of mild, moderate, and severe periodontitis according to the CDC/AAP case definitions.¹⁵
 ‡ Standardized to age distribution of the 2000 US population.
 § NHANES III protocol⁷ applied to NHANES 2009 to 2012 data; prevalence estimates based on the PMPE protocols used in NHANES III and 1999 to 2000 with PD and AL measurements from only two sites per tooth (mid-buccal and mesio-buccal sites) from all teeth other than third molars in two randomly selected quadrants.
 || NHANES 2001 to 2004 protocol⁷ applied to NHANES 2009 to 2012 data; prevalence estimates based on the PMPE protocol used in NHANES 2001 to 2004, using measurements of PD and AL from only three sites per tooth (mid-buccal, mesio-buccal, and disto-buccal) from all teeth other than third molars in two randomly selected quadrants.
 ¶ Oversampling of non-Hispanic Asian Americans only in NHANES 2011 to 2012.

Table 2. Prevalence of Respective Periodontitis Categories by CDC/AAP and EFP Case Definitions Among Adults Aged ≥30 Years by Selected Characteristics: NHANES 2009 to 2012

Characteristics	n	Weighted n (millions)*	Periodontitis (CDC/AAP Case Definitions ¹⁹)			Periodontitis (EFP Case Definitions ²¹)				
			Severe, %	SE	Other, %	SE	Severe, %	SE	Incipient, %	SE
NHANES 2009 to 2012	7,066	141.0	8.9	0.6	37.1	1.5	12.0	0.7	65.8	1.0
NHANES III protocol [†]	7,043	140.7	1.6	0.2	17.2	1.0	6.5	0.5	39.8	1.4
NHANES 2000 to 2004 protocol [‡]	7,044	140.7	3.1	0.4	23.2	1.0	7.9	0.5	42.4	1.4
Age (mean: 24 teeth)										
30 to 34 years	846	17.2	2.2	0.5	22.7	1.8	2.1	0.5	51.9	2.6
35 to 49 years	2,495	54.0	7.5	0.8	29.7	1.4	8.1	0.7	16.0	1.5
50 to 64 years	2,214	45.9	11.9	1.0	40.8	2.2	15.8	1.2	70.0	1.5
≥65 years	1,511	23.8	11.0	1.4	57.0	2.2	20.6	1.6	71.0	1.7
Sex										
Males	3,515	69.0	13.3	0.9	41.6	1.7	16.5	0.9	68.1	1.3
Females	3,551	72.0	4.7	0.5	32.7	1.7	7.6	0.6	63.6	1.1
Race/ethnic group										
Hispanic	1,028	11.0	15.8	1.7	47.7	1.9	16.8	1.4	70.3	1.6
Non-Hispanic Asian American [§]	478	7.6	12.1	2.0	37.8	2.6	12.6	2.5	73.0	2.1
Non-Hispanic white	3,018	97.0	6.8	0.7	34.0	1.9	9.9	0.9	65.4	1.4
Non-Hispanic black	1,512	15.1	15.6	1.4	43.5	1.5	19.2	1.6	61.6	1.5
Education										
Less than high school	1,784	23.1	17.1	1.5	49.9	1.7	24.7	1.6	62.5	1.7
High school/GED	1,514	29.5	11.9	0.9	43.8	2.0	17.7	1.4	65.3	1.6
More than high school	3,757	88.3	5.7	0.6	31.4	1.6	6.8	0.6	66.8	1.3
Income										
< 100% FPL	1,257	15.5	14.9	1.2	47.4	2.0	21.7	1.6	64.4	1.7
100% to 199% FPL	1,683	24.9	13.7	1.4	43.3	2.3	19.3	1.3	64.2	1.6
200% to 399% FPL	1,660	37.6	8.0	0.9	40.1	2.4	11.1	1.1	65.5	1.6
≥400% FPL	1,848	53.4	4.9	0.7	28.0	1.6	5.9	0.7	66.4	1.6
Marital status										
Married	4,049	88.4	7.4	0.6	34.4	1.6	10.1	0.6	65.0	1.0
Widowed	525	7.3	11.1	1.5	50.2	3.4	23.5	2.6	67.0	2.2
Divorced	874	17.1	12.5	1.6	41.1	3.2	15.8	2.1	67.9	2.9
Separated	296	3.8	17.3	3.9	43.3	4.4	19.7	3.5	65.4	3.4
Never married	821	14.8	7.8	1.2	37.0	2.0	9.5	1.1	67.6	2.0
Living with partner	495	9.5	12.7	1.7	41.3	3.3	14.2	1.8	66.3	3.1

Table 2. (continued)
Prevalence of Respective Periodontitis Categories by CDC/AAP and EFP Case Definitions Among Adults Aged ≥30 Years by Selected Characteristics: NHANES 2009 to 2012

Characteristics	n	Weighted n (millions)*	Periodontitis (CDC/AAP Case Definitions ¹⁹)			Periodontitis (EFP Case Definitions ²¹)				
			Severe, %	SE	Other, %	SE	Severe, %	SE	Incipient, %	SE
Smoking status										
Current smoker	1,338	24.6	18.9	1.7	47.7	2.1	25.6	1.8	62.0	2.0
Former smoker	1,769	37.1	9.5	1.0	39.2	2.4	13.5	1.2	66.9	1.6
Non-smoker	3,956	79.3	5.5	0.6	32.8	1.3	7.0	0.6	66.4	1.2

* Source population represented applying MEC weights.
 † NHANES III protocol¹ applied to NHANES 2009 to 2012 data: prevalence estimates based on the PMPE protocols used in NHANES III and 1999 to 2000 with PD and AL measurements from only two sites per tooth (mid-buccal and mesio-buccal sites) from all teeth other than third molars in two randomly selected quadrants.
 ‡ NHANES 2001 to 2004 protocol¹⁷ applied to NHANES 2009 to 2012 data: prevalence estimates based on the PMPE protocol used in NHANES 2001 to 2004 using measurements of PD and AL from only three sites per tooth (mid-buccal, mesio-buccal, and disto-buccal) from all teeth other than third molars in two randomly selected quadrants.
 § Oversampling of non-Hispanic Asian Americans only in NHANES 2011 to 2012.

data, 18.8% and 26.3%, respectively, of adults aged ≥30 years were estimated to have some type of periodontitis. During 2009 to 2012, the distribution of periodontitis in the adult US population based on the CDC/AAP case definitions was 8.9% for severe periodontitis and 37.1% for other periodontitis (Table 2). Similarly, when periodontitis was classified by the EFP definitions, an estimated 12.0% and 65.8% were detected for severe and incipient periodontitis, respectively.

The distributions of total periodontitis by race/ethnicity, as well as by socioeconomic and smoking status, are also shown in Table 1. Results are according to self-reported race and ethnicity in the four groups for which statistical reliability was adequate. Within the race/ethnic subgroups, data from 2011 to 2012 provide the first estimate of a prevalence of 50.0% total periodontitis among non-Hispanic Asian Americans. For the combined 2009 to 2012 period, periodontitis prevalence was highest in Hispanics (63.5%) and non-Hispanic blacks (59.1%), and least among non-Hispanic whites (40.8%). In addition, prevalence was highest among adults with less than high school education, adults below 100% of the federal poverty level (FPL), and current smokers.

In 2009 to 2012, 8.9% of adults ≥30 years old had severe periodontitis (Table 2). Within the sociodemographic groups studied, severe periodontitis was more prevalent among adults age ≥50 years, males, Hispanics and non-Hispanic blacks, those not completing high school, people living below 200% of FPL, and current smokers. These risk indicators showed a similar pattern for severe periodontitis when disease was classified by the EFP definition. Table 2 also shows the 2011 to 2012 distribution of periodontitis by case definitions among non-Hispanic Asian Americans; namely, ≈12% had severe periodontitis and 38% had other periodontitis.

The distribution of AL in 2009 to 2012 by selected thresholds is presented in Table 3. Approximately 88% had ≥1 sites with AL ≥3 mm, with the estimates reaching the highest prevalence (96.4%) among adults ≥65 years, closely followed by widowed adults (95.6%) and current smokers (93.6%). Overall, 14.7% of adults aged ≥30 years had the most severe attachment loss, i.e., AL ≥7 mm, and the highest prevalence was seen in adults with less than a high school education (27.9%) and current smokers (27.0%). Mean AL for the total adult population surveyed was 1.72 mm in 2009 to 2012. Results from 2011 to 2012 indicate that non-Hispanic Asian Americans experience a mean AL of 1.95 mm, and 15.4% had AL ≥7 mm.

Table 4 shows the distribution of PD in 2009 to 2012 by selected thresholds. Approximately 42% of adults had PD ≥4 mm at ≥1 sites. In contrast, the highest prevalence of PD ≥4 mm was seen among

Table 3.**Prevalence of AL by Severity and Overall Mean AL Among Adults Aged ≥ 30 Years by Selected Characteristics: NHANES 2009 to 2012**

Characteristics	Severity of AL, %										Mean AL, mm	SE
	≥ 3 mm	SE	≥ 4 mm	SE	≥ 5 mm	SE	≥ 6 mm	SE	≥ 7 mm	SE		
Total	88.1	0.8	60.8	1.6	40.9	1.4	24.2	1.0	14.7	0.6	1.72	0.03
Age (mean: 24 teeth)												
30 to 34 years	72.3	1.8	32.6	2.3	16.4	1.8	8.3	1.0	3.2	0.7	1.23	0.04
35 to 49 years	85.7	1.1	51.8	2.2	32.4	1.9	17.0	1.2	10.4	0.8	1.52	0.04
50 to 64 years	92.6	1.3	71.4	1.8	49.0	2.0	30.1	1.8	18.8	1.0	1.94	0.06
≥ 65 years	96.4	0.7	81.5	1.8	62.3	1.7	40.7	1.8	24.7	1.5	2.14	0.06
Sex												
Males	92.0	0.9	68.4	1.6	49.2	1.5	30.6	1.2	19.4	0.9	1.95	0.04
Females	84.4	1.1	53.6	1.9	33.0	1.7	18.0	1.1	10.1	0.7	1.50	0.03
Race/ethnic group												
Hispanic	95.0	0.9	71.6	1.6	52.1	2.5	33.9	2.0	21.8	1.7	2.01	0.06
Non-Hispanic Asian American*	92.9	0.8	65.0	3.3	41.2	3.2	27.4	3.1	15.4	2.0	1.95	0.11
Non-Hispanic white	86.6	1.2	57.2	2.0	37.0	1.8	20.5	1.3	11.8	0.8	1.62	0.04
Non-Hispanic black	90.0	1.3	69.7	2.1	51.1	2.0	35.7	2.0	23.7	1.5	2.09	0.08
Education												
Less than high school	93.7	0.9	77.0	1.7	59.8	1.8	42.0	2.3	27.9	1.6	2.35	0.07
High school/GED	90.2	1.1	68.2	2.0	48.9	1.7	30.8	1.8	20.4	1.0	1.95	0.05
More than high school	86.0	1.0	54.1	1.7	33.2	1.5	17.4	1.0	9.3	0.6	1.48	0.03
Income												
<100% FPL	92.4	1.4	71.8	1.6	52.4	1.4	35.2	1.6	23.2	1.4	2.25	0.06
100% to 199% FPL	92.9	0.9	68.4	1.5	48.3	1.7	32.2	1.6	21.4	1.2	2.04	0.05
200% to 399% FPL	87.4	1.2	63.0	2.7	43.2	2.7	24.9	2.1	14.5	1.2	1.69	0.05
$\geq 400\%$ FPL	84.8	1.4	51.3	2.0	31.0	1.7	15.6	0.9	8.4	0.7	1.43	0.03
Marital status												
Married	86.8	0.9	56.7	1.7	37.6	1.4	21.6	1.0	12.8	0.6	1.62	0.03
Widowed	95.6	1.2	79.7	2.3	59.1	3.1	38.8	2.3	24.0	2.0	2.15	0.08
Divorced	92.2	1.1	69.2	3.2	47.2	2.9	29.2	2.1	19.2	2.1	1.93	0.07
Separated	92.0	2.2	73.6	2.9	57.0	4.3	35.0	4.4	23.7	3.3	2.12	0.13
Never married	86.7	1.6	60.0	2.8	36.1	3.0	20.8	2.4	11.4	1.4	1.68	0.06
Living with partner	88.2	2.3	65.2	3.7	47.0	3.6	28.4	2.5	18.0	2.1	1.92	0.09
Smoking status												
Current smoker	93.6	1.0	75.2	1.4	58.3	1.8	41.6	1.9	27.0	1.6	2.40	0.08
Former smoker	89.6	1.1	65.8	2.3	43.9	2.5	27.8	2.0	16.4	1.3	1.78	0.06
Non-smoker	85.8	0.9	54.1	1.8	34.1	1.4	17.2	1.0	10.0	0.6	1.49	0.03

* Oversampling of non-Hispanic Asian Americans only in NHANES 2011 to 2012.

current smokers (63.1%), closely followed by Hispanics (62.7%) and adults living below 100% of FPL (59%). The highest prevalence of the most severe PD, i.e., PD ≥ 7 mm, was found in Hispanics (11.9%) and current smokers (6.8%). Mean PD for the total adult population examined was 1.61 mm in 2009 to 2012. About 5% of non-Hispanic Asian Americans had a PD ≥ 7 mm, and the mean PD was 1.54 mm in 2011 to 2012.

The severity and extent of AL and PD in 2009 to 2012 is shown in Table 5. At the probing site level, 58.2% of all adults had AL ≥ 3 mm in $\geq 5\%$ of their probed sites, whereas 21.3% had $\geq 30\%$ of their probed sites affected by AL ≥ 3 mm. For PD, 17.0% had PD ≥ 4 mm in $\geq 5\%$ of their probed sites, whereas 3.1% had $\geq 30\%$ of probed sites affected by PD ≥ 4 mm. At the tooth level, 80.1% of adults had $\geq 5\%$ of their teeth with AL ≥ 3 mm, whereas 47.4% had $\geq 30\%$ of their teeth affected by

Table 4.
Prevalence of Periodontal PD by Severity and Overall Mean PD Among Adults Aged ≥30 Years by Selected Characteristics: NHANES 2009 to 2012

Characteristics	Severity of PD, %										Mean PD, mm	SE
	≥3 mm	SE	≥4 mm	SE	≥5 mm	SE	≥6 mm	SE	≥7 mm	SE		
Total	79.6	1.2	42.1	1.3	19.6	1.0	10.2	0.8	4.1	0.4	1.61	0.02
Age (mean: 24 teeth)												
30 to 34 years	71.0	2.4	32.3	2.3	12.0	1.2	5.9	1.0	1.8	0.5	1.47	0.03
35 to 49 years	77.6	1.4	39.2	1.8	18.1	1.3	9.4	1.0	3.8	0.5	1.60	0.03
50 to 64 years	83.1	1.7	46.1	1.9	22.7	1.4	12.0	1.1	5.0	0.7	1.66	0.03
≥65 years	83.8	1.8	48.3	2.4	22.7	2.0	11.9	1.4	4.7	0.8	1.64	0.03
Sex												
Males	85.3	1.4	50.6	1.3	26.4	1.2	14.4	1.1	6.3	0.7	1.76	0.03
Females	74.1	1.4	34.0	1.5	13.1	0.9	6.2	0.7	2.0	0.4	1.46	0.02
Race/ethnic group												
Hispanic	91.5	1.1	62.7	2.4	35.9	2.9	21.6	2.4	11.9	2.0	1.95	0.05
Non-Hispanic Asian American*	80.5	3.0	45.4	3.0	22.9	2.6	12.3	1.8	5.1	0.9	1.54	0.07
Non-Hispanic white	76.9	1.6	36.9	1.6	15.6	1.2	7.5	0.8	2.6	0.3	1.52	0.03
Non-Hispanic black	86.5	1.3	56.8	1.8	31.8	2.2	18.6	1.8	8.2	1.0	1.89	0.05
Education												
Less than high school	86.4	1.4	59.4	1.6	32.3	2.5	17.5	1.6	7.4	1.1	1.96	0.05
High school/GED	83.7	2.1	50.1	2.1	25.6	1.4	13.4	1.3	5.0	0.7	1.71	0.04
More than high school	76.5	1.3	34.9	1.5	14.3	1.1	7.2	0.7	3.0	0.4	1.48	0.02
Income												
<100% FPL	87.9	1.1	59.0	1.6	30.6	1.6	16.1	1.4	6.2	1.1	1.92	0.03
100% to 199% FPL	84.8	1.4	53.1	1.7	25.1	1.9	14.1	1.5	6.0	0.8	1.80	0.04
200% to 399% FPL	80.8	1.5	42.9	2.3	20.4	1.9	10.5	1.1	4.3	0.6	1.59	0.03
≥400% FPL	73.0	2.1	30.2	1.7	12.2	1.3	5.6	0.7	2.3	0.4	1.43	0.03
Marital status												
Married	77.8	1.3	38.3	1.5	16.9	1.0	8.2	0.6	3.4	0.3	1.55	0.03
Widowed	80.5	2.7	45.8	3.5	23.0	2.7	12.9	1.8	5.1	1.3	1.66	0.04
Divorced	82.5	1.7	50.5	2.9	24.5	1.6	13.6	1.7	5.6	1.1	1.69	0.04
Separated	87.7	3.5	55.9	4.3	31.3	4.8	19.4	3.7	6.9	1.3	1.89	0.08
Never married	81.8	1.9	42.4	3.0	18.3	2.3	9.7	1.4	4.2	0.9	1.64	0.04
Living with partner	84.5	2.8	54.0	3.4	31.5	2.6	17.9	2.3	5.7	1.4	1.79	0.06
Smoking status												
Current smoker	88.7	1.4	63.1	1.7	34.6	2.2	18.5	2.1	6.8	1.1	1.99	0.05
Former smoker	80.5	1.4	43.5	2.2	18.6	1.4	10.4	1.1	4.9	0.7	1.58	0.03
Non-smoker	76.4	1.5	35.0	1.6	15.5	1.0	7.6	0.7	2.9	0.4	1.51	0.03

* Oversampling of Non-Hispanic Asian Americans only in NHANES 2011 to 2012.

AL ≥3 mm. For PD, 32.8% had ≥5% of their teeth affected by PD ≥4 mm, whereas 12.5% had ≥30% of their teeth affected by PD ≥4 mm.

DISCUSSION

Based on CDC/AAP case definitions for periodontitis, the results from this study indicate that about half of non-Hispanic Asian American adults have periodontitis compared to 60% of Hispanic and non-

Hispanic blacks. Non-Hispanic Asian Americans had mean PD prevalence similar to that of non-Hispanic whites and mean AL prevalence similar to that of Hispanics.

NHANES 2009 to 2012 estimated that ≈46% of US dentate adults aged ≥30 years (representing ≈141.0 million adults) had periodontitis, with 8.9% having severe periodontitis and 37.1% having other periodontitis, which was less severe. About 88% had

Table 5.**Site- and Tooth-Specific Prevalence and Extent of Periodontal PD and Clinical AL Among Adults Aged ≥ 30 Years by Severity: NHANES 2009 to 2012**

Extent	Severity									
	≥ 3 mm		≥ 4 mm		≥ 5 mm		≥ 6 mm		≥ 7 mm	
	%	SE	%	SE	%	SE	%	SE	%	SE
Site specific										
PD										
$\geq 5\%$ sites	44.9	2.2	17.0	0.9	6.3	0.6	2.4	0.3	0.6	0.09
$\geq 10\%$ sites	31.2	1.8	10.6	0.6	3.1	0.4	1.2	0.2	0.2	0.05
$\geq 30\%$ sites	12.8	1.0	3.1	0.4	0.8	0.1	0.2	0.04	0.02	0.01
Mean	11.9	0.7	3.8	0.2	1.2	0.1	0.5	0.05	0.1	0.01
AL										
$\geq 5\%$ sites	58.2	1.6	31.8	1.4	17.3	0.8	9.7	0.5	5.3	0.4
$\geq 10\%$ sites	43.8	1.6	21.9	1.0	11.7	0.6	6.4	0.4	3.6	0.3
$\geq 30\%$ sites	21.3	1.0	10.0	0.7	5.0	0.4	2.9	0.3	1.6	0.2
Mean	19.3	0.8	9.8	0.5	5.2	0.3	2.9	0.2	1.5	0.1
Tooth specific										
PD										
$\geq 5\%$ sites	70.6	1.6	32.8	1.2	14.6	0.8	7.1	0.7	2.5	0.3
$\geq 10\%$ sites	61.4	1.9	25.7	0.9	10.4	0.7	4.6	0.5	1.5	0.2
$\geq 30\%$ sites	35.5	2.0	12.5	0.7	3.9	0.4	1.5	0.2	0.3	0.05
Mean	28.4	1.3	10.6	0.5	3.7	0.3	1.6	0.2	0.5	0.05
AL										
$\geq 5\%$ sites	80.1	1.1	49.5	1.7	31.5	1.2	18.0	0.8	10.7	0.5
$\geq 10\%$ sites	73.2	1.4	42.4	1.5	24.7	0.9	13.4	0.6	7.9	0.5
$\geq 30\%$ sites	47.4	1.7	23.4	1.0	12.0	0.7	6.4	0.4	3.5	0.3
Mean	37.4	1.1	19.2	0.8	10.6	0.5	5.9	0.3	3.2	0.2

AL ≥ 3 mm and 42% PD ≥ 4 mm at ≥ 1 sites. These findings are consistent with the authors' previous report based on 2009 to 2010 NHANES,¹ signifying a much higher prevalence of periodontitis in the adult US population than previously reported. These US estimates appear to be much lower than those reported from certain European populations. For example, a large population-based study in West Pomerania in the former East Germany used the original CDC/AAP no/mild, moderate, and severe case definitions²⁰ among 3,255 persons aged 20 to 79 years, assessing four sites on all teeth other than third molars in two quadrants (half-mouth).²³ They found 20.0% (versus 8.9% in NHANES 2009 to 2012) with severe and 35.3% (versus 30.9%) moderate periodontitis, leaving less than half (44.7%) of the population with only mild or no periodontitis.²³ This is in spite of inclusion of individuals ≤ 10 years younger than the NHANES participants and exclusion of those ≥ 80 years old.

The present findings confirm disparities in the burden of periodontitis by sociodemographic segments of the population. Beginning in 2011 to 2012, for the

first time in any US national examination survey, NHANES oversampled non-Hispanic Asian Americans to generate more stable prevalence estimates in that subpopulation. Among racial and ethnic groups, Hispanics had the highest prevalence of periodontitis, closely followed by non-Hispanic blacks, then non-Hispanic Asian Americans, and non-Hispanic whites had the lowest. The prevalence of periodontitis increased with increasing poverty levels and lower education, with $\approx 62\%$ of persons with $<100\%$ of FPL having periodontitis. Overall, the highest prevalence of periodontitis in the adult US population was seen among Hispanics, adults with the lowest education, with $<100\%$ of FPL, and current smokers. These sociodemographic patterns remain consistent with findings from previous NHANES,^{1,24} although more detailed multivariable analyses controlling for factors associated with prevalence of periodontitis will be required to confirm these observations.

Strengths and Limitations

The greatest strengths of this report are the large dataset combined from two nationally representative

NHANES survey cycles and the unprecedented application of an FMPE protocol that together result in the hitherto most valid representation of persons, teeth, and sites assessed. Examining all 28 teeth is superior to assessing only index teeth (or their replacements) or all seven teeth in random quadrants (excluding the third molars) in estimating disease prevalence.^{9,10,13,14} Moreover, the gold standard in clinical periodontal examinations is clinical assessment for periodontal measures at six sites around each tooth. For the first time in the history of NHANES, the 2009 to 2012 cycles applied this gold standard and assessed both periodontal PD and location of the CEJ for clinical AL to be calculated. This protocol allows estimation of the true presence of periodontitis, as periodontitis is defined as a combination of PD and AL. Examining all teeth and probing six sites on each for both PD and CEJ optimizes the potential to capture true disease. Additionally, the comprehensive FMPE optimizes the utilization of standard case definitions for surveillance of periodontitis and is hence more likely to capture true disease. Collectively, these factors ensure minimal misclassification of disease status in the population and produce a historic dataset that is highly superior to previous NHANES data for surveillance and epidemiologic research alike.

However, several factors may still have led to underestimation of disease prevalence. Notably, using conservative case definitions that do not incorporate measurements from all six sites may underestimate disease. For example, the conservative CDC/AAP case definitions are based on only measurements from the four interproximal sites due to the assumption that those sites are most often affected. Thus, measurements from the mid-buccal and the mid-lingual sites—which potentially could indicate furcation involvement—are not included in the prevalence calculations. In addition, neither BOP (indicative of active inflammation) nor furcation involvement was assessed, although such measures could provide additional information regarding periodontal disease status when applying different case definitions. These prevalence estimates only include gingivitis that may accompany periodontitis cases detected but do not include individuals with gingivitis only, owing to lack of measurements of gingivitis. Hence, the prevalence of cases that include all forms of periodontal disease would likely be even higher. No data were collected around third molars, so any disease present on those teeth was automatically missed. Finally, exclusion of individuals for medical reasons, incomplete oral examinations for any reason, and not sampling institutionalized persons, for instance nursing home residents, may have introduced some selection bias.

CONCLUSIONS

In conclusion, this study confirms the high burden of periodontitis in the United States, with nearly half (45.9%) the population aged ≥ 30 years affected. A better understanding of the factors influencing these findings and the disparities among sociodemographic groups is important for public health action to prevent and control periodontitis in US adults. Also, these findings provide a firm baseline for comparison with future NHANES studies to determine trends in periodontitis in US adults.

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- Correspondence: Dr. Paul I. Eke, Division of Population Health, National Center for Chronic Disease and Health Promotion, CDC, Atlanta, GA 30341. Fax: 770/488-5964; e-mail: peke@cdc.gov.
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