

Destructive Periodontal Disease in Adults 30 Years of Age and Older in the United States, 1988-1994*

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Background: Accurate information on the prevalence and extent of periodontal diseases in the United States adult population is lacking. This study estimated the prevalence and extent of periodontal disease in the United States using data from the third National Health and Nutrition Examination Survey (NHANES III).

Methods: A nationally representative sample was obtained during 1988 to 1994 by a stratified, multi-stage probability sampling design. A subsample of 9,689 dentate persons 30 to 90 years old who received a periodontal examination was used in this study, representing approximately 105.8 million civilian, non-institutionalized Americans in 1988 to 1994. Periodontal attachment loss, probing depth, and furcation involvement were assessed in 2 randomly selected quadrants per person. Attachment loss and probing depth were assessed at 2 sites per tooth, the mesio-buccal and mid-buccal surfaces. The periodontal status of each subject was assessed by criteria based on the extent and severity of probing depth and furcation involvement. These assessments were used to classify each subject as having a mild, moderate, or advanced form of the disease. In the analyses, weighted data were used to reflect the complex sampling method.

Results: Prevalence of attachment loss ≥ 3 mm was 53.1% for the population of dentate U.S. adults 30 to 90 years of age and, on average, 19.6% of teeth per person were affected. The prevalence of probing depth ≥ 3 mm was 63.9% and, on average, 19.6% of teeth were affected. Fourteen percent of these persons had furcation involvement in one or more teeth. We estimate that at least 35% of the dentate U.S. adults aged 30 to 90 have periodontitis, with 21.8% having a mild form and 12.6% having a moderate or severe form. The prevalence and extent of attachment loss and the prevalence of periodontitis increase considerably with age. However, the prevalence of moderate and advanced periodontitis decreases in adults 80 years of age and older. This is most likely attributed to a combination of a high prevalence of tooth loss and gingival recession in the oldest age cohorts. Attachment loss and destructive periodontitis were consistently more prevalent in males than females, and more prevalent in blacks and Mexican Americans than whites. We estimate that in persons 30 years and older, there are approximately 56.2 and 67.6 million persons who, on average, have about a third of their remaining teeth affected by ≥ 3 mm attachment loss and probing depth, respectively. We also estimate that about 21 million persons have at least one site with ≥ 5 mm attachment loss, and 35.7 million persons have periodontitis. These are conservative estimates based on partial-mouth examinations, and the true prevalence and extent of periodontal disease may be significantly higher than what is reported here.

Conclusions: Periodontitis is prevalent in the U.S. adult population. The results show that black and Mexican American males have poorer periodontal health than the rest of the U.S. adult population. Primary and secondary preventive measures should therefore be specifically targeted towards these groups. *J Periodontol* 1999; 70: 13-29.

KEY WORDS

National Health and Nutrition Examination Survey III; furcation/epidemiology; periodontal diseases/epidemiology; periodontal attachment loss/epidemiology; periodontal pockets/epidemiology; periodontitis/epidemiology; blacks; Mexican Americans.

Periodontal diseases and dental caries are the most prevalent oral diseases and are also the primary causes of loss of permanent teeth in man. Destructive periodontal diseases are characterized by loss of the supporting tissues of the teeth. This loss often compromises function and esthetics and may also be associated with pain and discomfort. In addition, there is recent evidence suggesting that destructive periodontitis may be a risk factor for some health problems including cardiovascular disease and low birth weight.¹⁻³ Hence, obtaining information on the prevalence and extent of these diseases is important for the assessment of the oral, and possibly, also the general health of the population.

Assessment of the prevalence and extent of periodontal diseases often has been achieved by measurement of periodontal attachment loss and/or probing depth. Attachment loss is a measure of previous disease experience and may not accurately represent the present status of disease. Probing depth, although not an ideal criterion of disease, is better

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Table 1.
Number of Persons Examined for Periodontal Condition During 1988-1994, by Age, Gender, and Race/Ethnicity, and the Corresponding Total Population for the Census 1990

	Sample		Total Population (in thousands)	
	No.	%	No.	%
Age (years)				
30-39	3,052	31.5	38,293	36.2
40-49	2,247	23.2	28,472	26.9
50-59	1,411	14.6	16,280	15.4
60-69	1,534	15.8	12,788	12.1
70-79	947	9.8	7,406	7.0
80-90	498	5.1	2,554	2.4
Gender				
Males	4,594	47.4	51,150	48.3
Females	5,095	52.6	54,643	51.7
Race/ethnicity				
Non-Hispanic whites	3,956	40.8	81,179	76.7
Non-Hispanic blacks	2,699	27.9	11,263	10.6
Mexican Americans	2,636	27.2	5,031	4.8
Others	398	4.1	8,320	7.9
Total	9,689	100	105,793	100

suiting to measure the present status of periodontitis than the measurement of attachment loss.

Accurate information on the prevalence and extent of periodontal diseases in the United States population is scarce. A number of factors have attributed to this. Studies often use regional data, which usually are not representative of the whole U.S. population. In addition, there is no consensus on a single examination method or diagnostic criteria for screening for the presence of periodontitis. Other constraints include measurement thresholds used, issues of reliability and validity of measurements, number of sites and teeth examined, and how tooth loss is accounted for in the estimates.

A survey of the oral health of U.S. employed adults and older persons in senior centers was conducted by the National Institute of Dental Research (NIDR) in 1985 to 1986, and the findings for periodontal parameters are reported elsewhere.^{4,5} The third National Health and Nutrition Examination Survey (NHANES III) was conducted by the National Center for Health

Statistics during the period 1988 to 1994. The periodontal status of Americans from data gathered during phase 1 (1988 to 1991) of NHANES III was reported earlier.⁶

The aims of this study were to: 1) assess the prevalence and extent of periodontal attachment loss, probing depth, and furcation involvement in U.S. adults aged 30 years and older using data from the entire NHANES III survey (phases 1 and 2); and 2) estimate the periodontal status in the U.S. adult population during this period.

MATERIALS AND METHODS

Study Design

NHANES III was designed to assess the health of the United States population during the period 1988 to 1994 and to generate national estimates of a wide range of health and nutrition characteristics.⁷⁻⁹ The survey was undertaken in 2 successive phases, with phase 1 data collected during 1988 to 1991 and phase 2 during 1992 to 1994. In this report, we use the combined data from both phases.

The NHANES III survey studied a nationally representative sample of persons obtained by a stratified, multi-stage probability sampling design. National estimates computed using the entire survey (i.e., 1988 to 1994) produce more precise estimates than those for individual phase estimates, and further allow one to produce more precise estimates for health conditions within a variety of subgroups as well. The protocol for NHANES III was approved by the Institutional Review Board of the National Center for Health Statistics.

Study Sample

Of the 30,818 persons who received a health examination in the NHANES III survey, 11,111 persons were dentate in the age group 30 years or older, and 10,740 (96.7%) of these also received a dental examination. For the periodontal examination, 933 (8.7%) persons were excluded for medical reasons, and 118 (1.1%) persons were excluded for various other reasons. Medical exclusion criteria included cardiovascular diseases and other conditions that may have required the use of antibiotics before the periodontal examination.

The study group consisted of 9,689 individuals 30 to 90 years old who received a periodontal examination during the NHANES III survey. They represented approximately 105.79 million civilian, non-institutionalized Americans. The distribution of these individuals by age group, gender, and race/ethnicity and the frequency of the total population that they represent are

shown in Table 1. The sampling design involved selecting primary sampling units (counties) by a probability method with oversampling of older groups, non-Hispanic blacks, and Mexican Americans.

Clinical Examination

The examinations and data collection were conducted in mobile examination centers that included dental units. The oral examination was done by trained dentists, and the data were entered directly by a health technician who used an automated computer data entry program. Of the oral health parameters assessed in the NHANES III survey, we describe in this report the variables relating to the measurement of periodontal supporting tissues; they include attachment loss, probing depth, and furcation involvement. The periodontal examination was carried out in 2 randomly selected quadrants, one maxillary and one mandibular. In the 2 quadrants, all fully erupted teeth were assessed, excluding third molars. A maximum of 14 teeth per individual were examined.

The distance from the cemento-enamel junction (CEJ) to the free gingival margin (FGM) and the distance from the FGM to the bottom of the pocket/sulcus were assessed at the mesio-buccal and mid-buccal surfaces. The measurements were made in millimeters and were rounded to the lowest whole millimeter. The assessment was made by using the NIDR periodontal probe. The probing depth was defined as the FGM/sulcus measurement. The CEJ/FGM distance was given a negative sign if the gingival margin was located on the root. Attachment loss was defined as the distance from the CEJ to the bottom of the pocket/sulcus and was calculated as the difference between the CEJ/FGM and FGM/sulcus distances (or the sum of the 2 distances if the FGM was on the root).

Assessment of furcation involvement was made on 5 posterior teeth. The assessments were made at the mesial, buccal, and distal furcations of maxillary first and second molars, the mesial and distal furcations of maxillary second premolars, and the buccal and lingual furcations of mandibular first and second molars. Explorer #17 was used for maxillary molars and premolars, and explorer #3 for mandibular molars. Partial furcation involvement (grade I) was scored in sites where the explorer was definitely catching into but did not pass through the furcation. Total furcation involvement (grade II) was used when the explorer could be passed between the roots and through the entire furcation.

Classification by Extent and Severity of Periodontitis

For the purpose of this study, periodontitis was defined as a disease state in which there was an active destruction of the periodontal supporting tissues as evidenced by the presence of ≥ 3 mm probing depth and ≥ 3 mm periodontal attachment loss at the same site. Accordingly, the probing depth here denotes the

FGM/sulcus distance, where the gingival margin is at or apical to the CEJ (true pocket).

Individuals with less than 6 teeth present (out of a maximum of 28 teeth) were not included in the classification for severity of periodontal disease. The individuals were classified according to extent and severity of periodontal disease using the following criteria:

Advanced periodontitis: 1) two or more teeth (or 30% or more of the teeth examined) having ≥ 5 mm probing depth, or 2) four or more teeth (or 60% or more of the teeth examined) having ≥ 4 mm probing depth, or 3) one or more posterior teeth with grade II furcation involvement.

Moderate periodontitis: 1) one or more teeth with ≥ 5 mm probing depth, or 2) two or more teeth (or 30% or more of the teeth examined) having ≥ 4 mm probing depth, or 3) one or more posterior teeth with grade I furcation involvement and accompanied with ≥ 3 mm probing depth.

Mild periodontitis: 1) one or more teeth with ≥ 3 mm probing depth, or 2) one or more posterior teeth with grade I furcation involvement.

No periodontitis: persons with 6 or more teeth who did not fulfill any of the above criteria were regarded as not having detectable levels of periodontitis.

Each person was assigned a given classification if he/she fulfilled one or more of the criteria of that classification, and was given the most advanced classification.

Data Analysis

Prevalence of a given periodontal condition was defined as the percentage of persons having at least one site with that condition, and the extent was defined as the percentage of teeth per person displaying that condition. For attachment loss and probing depth, the extent estimates were based on clinical examination of a maximum of 14 teeth, and for furcation involvement, the extent estimates were based on examination of 5 posterior teeth.

The race/ethnicity variable was self-reported and was derived from separate questions on race and ethnicity obtained during a household interview. Throughout the text, the term whites will be used to designate non-Hispanic whites, and blacks will be used for non-Hispanic blacks.

Because of the complex sampling design of NHANES III, each sampled person did not have an equal probability of selection, and final sample weights were used to produce unbiased population estimates. The 1990 Census estimates of the U.S. population were used for standardization of the data to adjust for differences in age in the subpopulations. For all the data analyses, the software package SUDAAN¹⁰ was used to calculate standard errors. Estimates of attachment loss and probing depth for the whole group were standardized by gender and race/ethnicity, whereas

Attachment loss

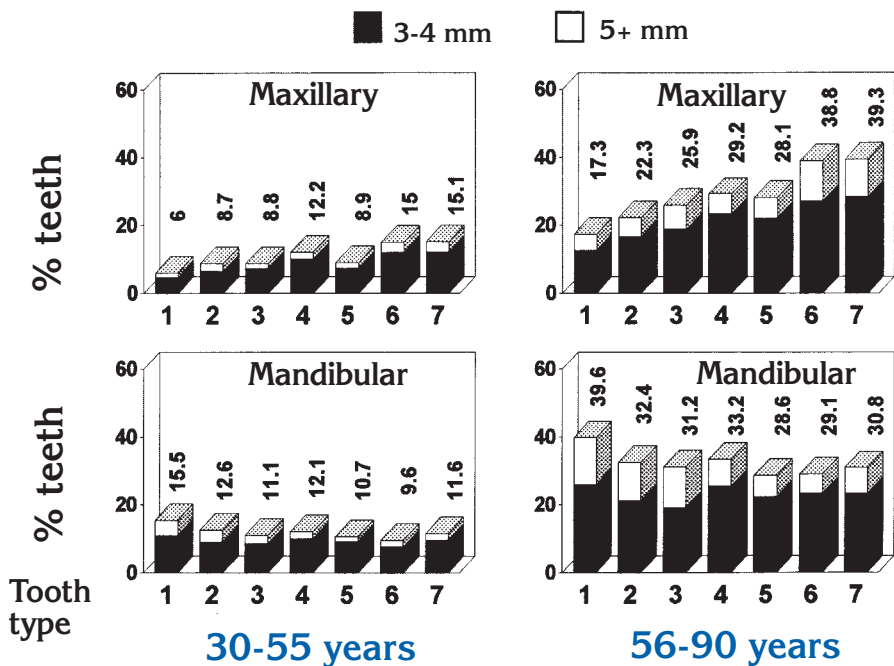


Figure 1. Percentage of teeth by amount of attachment loss, tooth, and age group. Central incisors: 1, second molars: 7.

to estimate inter- and intra-examiner reliability. The intraclass correlation coefficients for mean and extent scores of attachment loss and probing depth were between 0.75 and 0.97. The inter- and intra-examiner reliability of qualitative subject level prevalence (maximum) scores and all site-based probing depth or attachment level measurements were assessed by weighted and unweighted (exact) kappa statistics. The exact kappa coefficients for interexaminer reliability of subject level prevalence scores ranged between 0.25 and 0.50, and the weighted kappas (within ± 1 mm) ranged between 0.55 and 0.89. The examiners could agree on attachment level and pocket depth scores within ± 1 mm consistently. However, the low values of exact kappa suggest that some differences exist among the examiners regarding prevalence values, since a 1 mm difference could affect these values to some degree.

estimates for subgroups of gender were standardized by race/ethnicity only, and estimates for subgroups of race/ethnicity were standardized by gender only. Comparisons by gender used estimates standardized by age cohort and race/ethnicity, and comparisons by race/ethnicity used estimates standardized by age cohort and gender.

Measurement Reliability

The NHANES III field staff followed a quality control protocol mandated for data collection for the entire survey (a detailed description is given by Drury et al.¹¹). This involved standard examination environment and methodology, standard state-of-the-art equipment, and detailed written instructions for all procedures. The protocol was aimed at reducing systematic and random measurement errors and quantifying what error remained. The dental examiners received formal training and calibration in assessing the periodontal and other oral variables both before and during the study. Intra-examiner reliability assessments were based on replicate examinations conducted on random recall samples of roughly 20 study participants at each of the NHANES III 89 survey locations. Interexaminer bias and reliability were evaluated indirectly by making separate comparisons of each survey examiner with the “reference” examiner.

For continuous type responses such as subject level counts, the intraclass correlation coefficients were used

Measurement errors for individual examiners were estimated by using the differences between replicate measurements for the individual site assessments.

The intra-examiner measurement errors of attachment loss and probing depth were between 0.25 mm and 0.55 mm.

RESULTS

Attachment Loss

Overall, the prevalence of ≥ 3 mm attachment loss was 53.1%, representing 56.2 million adults, and the extent was 19.6% teeth per person. Affected persons had, on average, 36.6% affected teeth. For each millimeter diagnostic threshold, the prevalence and extent of attachment loss increased steadily with increasing age cohort (Tables 2 and 3). In the age cohort 30 to 39 years, the prevalence and extent of ≥ 3 mm attachment loss were 35.7% of persons and 8.1% of teeth, but the corresponding scores for the age group 80 to 90 years were two and a half times (89.2% of persons) and six times (50% of teeth) as large, respectively. A comparison by gender showed that the prevalence and the extent of attachment loss were consistently higher in males than in females ($P < 0.0001$) (Table 4). For race/ethnicity, the prevalence was highest for blacks, significantly lower for Mexican Americans, and lowest for whites. All 3 groups were statistically separable pairwise ($P < 0.001$).

At the tooth-specific level, maxillary molars and mandibular incisors were affected more frequently by ≥ 3 mm attachment loss than other teeth, whereas maxillary central incisors were the least affected teeth (Fig. 1). Large differences by age group in tooth-specific

Table 2.

Prevalence of Persons by Degree of Attachment Loss and Age Cohort

Attachment Loss	Age (Years)													
	30-39		40-49		50-59		60-69		70-79		80-90		Total	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
All persons*														
≥1 mm	97.42	0.65	99.61	0.18	99.67	0.20	99.67	0.19	99.70	0.20	99.82	0.20	98.86	0.24
≥2 mm	67.15	2.13	81.31	1.55	87.01	1.52	92.63	1.47	95.48	1.10	96.91	0.99	80.04	1.23
≥3 mm	35.74	1.45	48.49	1.95	66.43	1.66	74.84	2.54	79.02	2.16	89.19	1.56	53.13	1.18
≥4 mm	17.48	1.37	27.23	1.33	44.62	1.96	53.21	2.96	57.40	2.12	71.12	3.20	32.74	1.06
≥5 mm	7.97	0.98	16.66	1.20	26.87	1.69	35.31	2.34	41.71	2.06	51.36	3.43	19.90	0.94
≥6 mm	4.19	0.68	9.53	0.91	15.76	1.22	23.54	1.87	25.84	1.99	34.62	2.48	11.86	0.76
≥7 mm	2.54	0.51	5.68	0.78	9.39	1.09	15.35	1.43	16.96	1.78	20.53	2.25	7.26	0.55
Males †														
≥1 mm	97.60	0.87	99.66	0.21	99.91	0.06	99.87	0.09	99.43	0.42	100	0	98.97	0.27
≥2 mm	71.98	2.76	83.84	2.13	89.37	2.21	94.49	1.41	96.76	0.90	96.71	1.43	82.72	1.47
≥3 mm	42.05	2.56	53.96	2.33	71.73	2.28	79.61	2.29	82.36	2.23	91.00	2.00	57.82	1.27
≥4 mm	22.27	2.62	33.84	1.73	52.67	2.67	59.76	3.42	62.43	2.81	72.15	5.10	37.94	1.12
≥5 mm	9.37	1.73	22.18	1.89	34.37	2.21	41.13	3.45	46.70	3.05	54.31	5.37	23.60	1.18
≥6 mm	5.43	1.11	13.43	1.52	21.25	1.64	30.27	2.78	32.03	2.64	37.85	4.39	15.17	1.04
≥7 mm	3.22	0.79	7.62	1.32	13.23	1.70	20.47	2.43	22.84	2.78	24.92	3.81	9.53	0.85
Females †														
≥1 mm	97.24	0.82	99.56	0.25	99.45	0.39	99.47	0.36	99.96	0.04	99.65	0.39	98.75	0.33
≥2 mm	62.56	2.59	78.89	1.85	84.77	1.71	90.87	2.04	94.25	1.56	97.10	1.39	77.48	1.40
≥3 mm	29.73	2.08	43.28	2.22	61.40	2.48	70.31	3.69	75.84	3.16	87.46	2.35	48.67	1.54
≥4 mm	12.93	1.09	20.94	2.02	36.98	2.51	46.97	3.79	52.62	2.81	70.11	3.15	27.79	1.34
≥5 mm	6.64	0.86	11.40	1.42	19.73	2.21	29.77	2.89	36.95	2.85	48.54	3.53	16.36	1.05
≥6 mm	3.00	0.53	5.80	1.03	10.54	1.43	17.14	2.14	19.93	2.48	31.53	2.95	8.72	0.76
≥7 mm	1.90	0.48	3.82	0.78	5.74	1.18	10.48	1.27	11.36	1.82	16.33	2.39	5.09	0.49
Non-Hispanic whites‡														
≥1 mm	97.24	0.73	99.68	0.18	99.71	0.22	99.73	0.20	99.68	0.23	100	0	98.84	0.26
≥2 mm	66.73	2.40	80.83	1.62	86.72	1.70	92.41	1.61	95.66	1.18	96.74	1.13	79.78	1.32
≥3 mm	34.38	1.67	47.03	2.16	65.88	1.90	72.64	2.73	77.01	2.54	87.44	1.91	52.04	1.26
≥4 mm	16.22	1.48	26.06	1.53	43.56	2.18	50.88	3.23	54.53	2.50	67.28	3.65	31.66	1.11
≥5 mm	7.23	1.02	15.51	1.31	26.04	1.86	32.82	2.62	39.47	2.35	47.19	3.84	19.02	0.98
≥6 mm	3.73	0.69	8.60	0.96	14.54	1.35	21.03	2.04	23.11	2.20	30.30	2.73	10.97	0.77
≥7 mm	2.19	0.53	4.96	0.87	8.77	1.30	13.68	1.56	14.69	2.04	16.83	2.30	6.63	0.59
Non-Hispanic blacks‡														
≥1 mm	98.21	0.77	99.18	0.33	99.46	0.32	99.29	0.42	100	0	98.44	1.73	98.86	0.43
≥2 mm	76.16	1.80	87.20	1.66	90.03	1.93	92.58	2.10	94.01	2.83	98.44	1.73	84.00	1.39
≥3 mm	47.03	1.60	61.25	1.40	76.95	2.63	85.09	3.49	86.74	3.28	98.44	1.73	61.57	1.26
≥4 mm	24.46	1.43	39.70	1.62	57.79	3.64	68.86	4.08	73.13	4.40	92.02	2.83	41.02	1.56
≥5 mm	13.39	1.28	28.40	1.57	37.19	2.74	54.98	2.88	56.57	4.10	76.51	5.86	27.95	1.18
≥6 mm	8.20	1.20	18.06	1.38	26.20	2.58	37.55	3.14	43.04	3.50	58.71	5.26	18.71	0.97
≥7 mm	4.65	0.81	11.63	1.05	16.54	2.49	26.80	2.55	31.15	2.94	44.34	7.12	12.23	0.75
Mexican Americans‡														
≥1 mm	98.97	0.90	100	0	100	0	100	0	100	0	100	0	99.60	0.38
≥2 mm	81.08	6.92	92.78	2.64	89.50	5.54	80.21	8.34	100	0	100	0	86.38	3.25
≥3 mm	54.53	7.69	63.77	7.60	77.35	8.34	76.02	8.47	92.08	7.27	100	0	64.51	4.88
≥4 mm	35.42	7.68	34.91	6.86	63.70	10.05	63.81	9.16	73.25	12.74	84.55	15.24	44.31	4.72
≥5 mm	23.70	6.62	15.29	4.92	54.01	10.55	31.87	10.86	26.31	13.80	62.21	21.31	28.35	3.65
≥6 mm	12.74	5.32	7.13	3.58	21.95	9.68	24.38	8.24	25.84	13.69	62.21	21.31	14.58	2.46
≥7 mm	9.83	6.14	4.45	3.05	16.92	9.01	3.80	2.86	25.06	13.72	11.93	11.13	9.69	1.83

*Standardized by gender and race/ethnicity.

†Standardized by race/ethnicity.

‡Standardized by gender.

Table 3.

Mean Percentage of Teeth by Degree of Attachment Loss and Age Cohort

Attachment Loss	Age (Years)													
	30-39		40-49		50-59		60-69		70-79		80-90		Total	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
All persons*														
<1 mm	27.11	2.19	17.94	1.39	12.00	1.28	8.76	1.13	7.72	1.02	4.53	0.80	18.10	1.41
1 mm	48.43	1.37	45.89	0.95	37.18	1.09	33.56	1.48	29.41	1.52	24.86	1.95	42.30	0.85
2 mm	16.39	1.26	20.05	0.97	23.05	1.02	23.11	1.08	23.96	1.70	20.57	1.52	19.99	0.96
3 mm	4.84	0.29	7.93	0.41	12.30	0.58	13.82	0.69	15.07	0.77	17.90	0.92	8.98	0.28
4 mm	1.72	0.19	3.60	0.23	7.13	0.53	8.70	0.72	9.56	0.57	13.08	1.20	4.76	0.19
5 mm	0.75	0.13	1.90	0.23	3.85	0.33	5.01	0.44	6.22	0.50	8.66	0.98	2.62	0.14
6 mm	0.36	0.08	1.23	0.20	2.03	0.21	2.89	0.33	3.42	0.36	4.37	0.55	1.45	0.10
≥7 mm	0.40	0.10	1.46	0.31	2.45	0.33	4.15	0.59	4.65	0.58	6.02	0.89	1.81	0.19
≥3 mm	8.07	0.62	16.13	0.77	27.76	1.17	34.57	1.81	38.91	1.60	50.04	2.71	19.62	0.72
Males†														
<1 mm	24.63	2.33	15.75	1.60	9.36	1.43	7.22	0.92	7.07	1.03	3.84	0.74	16.24	1.33
1 mm	46.20	1.31	42.65	1.23	33.07	1.56	29.46	1.82	26.24	1.78	23.27	2.13	39.59	0.84
2 mm	19.15	1.68	20.61	1.12	24.84	1.43	22.96	1.16	24.38	2.05	19.24	1.65	21.29	1.06
3 mm	5.84	0.54	9.60	0.65	13.12	0.82	14.93	0.95	15.51	0.91	17.36	1.27	9.93	0.33
4 mm	2.18	0.28	4.70	0.44	8.47	0.75	9.20	0.82	10.31	0.82	13.44	1.49	5.39	0.22
5 mm	0.92	0.20	2.70	0.43	4.91	0.61	6.07	0.74	5.90	0.55	10.03	1.49	3.09	0.18
6 mm	0.47	0.12	1.94	0.41	2.86	0.32	4.14	0.60	4.10	0.54	5.11	0.93	1.98	0.18
≥7 mm	0.60	0.19	2.06	0.54	3.38	0.52	6.02	1.06	6.50	0.89	7.71	1.47	2.49	0.31
≥3 mm	10.01	0.96	20.99	1.24	32.74	1.46	40.36	2.36	42.32	1.91	53.65	3.23	22.88	0.76
Females‡														
<1 mm	29.46	2.48	20.02	1.51	14.52	1.54	10.22	1.63	8.34	1.30	5.19	1.22	19.87	1.58
1 mm	50.54	1.81	48.98	1.18	41.09	1.30	37.46	1.95	32.42	1.79	26.38	2.39	44.88	1.02
2 mm	13.77	1.23	19.51	1.10	21.36	1.12	23.25	1.41	23.58	1.62	21.83	1.80	18.75	0.96
3 mm	3.89	0.41	6.35	0.39	11.52	0.75	12.76	0.85	14.65	1.13	18.41	1.21	8.08	0.36
4 mm	1.29	0.17	2.55	0.26	5.85	0.74	8.23	1.05	8.83	0.94	12.75	1.37	4.16	0.28
5 mm	0.59	0.13	1.14	0.26	2.84	0.43	4.00	0.58	6.53	0.84	7.36	1.01	2.16	0.19
6 mm	0.24	0.07	0.55	0.15	1.24	0.22	1.71	0.41	2.77	0.48	3.67	0.63	0.95	0.11
≥7 mm	0.21	0.06	0.89	0.26	1.58	0.36	2.36	0.35	2.89	0.57	4.40	0.93	1.16	0.14
≥3 mm	6.23	0.68	11.49	0.78	23.03	1.67	29.07	2.19	35.67	2.39	46.60	3.28	16.50	0.87
Non-Hispanic whites†														
<1 mm	27.53	2.31	17.91	1.48	12.23	1.39	9.15	1.23	8.01	1.06	4.88	0.93	18.22	1.49
1 mm	48.63	1.48	47.22	0.98	38.14	1.18	35.27	1.63	30.14	1.69	26.95	2.15	43.01	0.88
2 mm	16.02	1.30	19.64	0.98	23.05	1.08	23.25	1.16	25.26	1.98	21.13	1.69	19.82	1.00
3 mm	4.77	0.32	7.49	0.46	12.12	0.57	13.33	0.71	14.69	0.81	17.82	0.88	8.80	0.28
4 mm	1.63	0.20	3.37	0.27	6.92	0.56	8.29	0.78	9.25	0.63	13.01	1.39	4.62	0.20
5 mm	0.74	0.14	1.89	0.27	3.63	0.37	4.76	0.54	6.08	0.61	7.74	1.03	2.58	0.16
6 mm	0.34	0.09	1.16	0.22	1.83	0.24	2.58	0.36	2.96	0.38	4.03	0.61	1.36	0.11
≥7 mm	0.35	0.10	1.31	0.32	2.09	0.35	3.37	0.62	3.61	0.62	4.44	0.83	1.59	0.20
≥3 mm	7.82	0.67	15.23	0.85	26.58	1.25	32.33	1.98	36.59	1.79	47.04	3.05	18.95	0.74
Non-Hispanic blacks‡														
<1 mm	23.27	2.07	15.55	1.43	9.00	1.35	6.59	1.40	5.57	1.83	3.30	1.88	16.32	1.46
1 mm	44.83	1.27	38.58	1.31	30.91	1.99	24.30	2.32	22.51	2.29	12.59	4.13	37.62	1.29
2 mm	20.20	1.47	22.81	1.51	20.70	1.37	20.55	1.43	18.57	2.15	16.98	3.03	20.94	1.15
3 mm	6.58	0.44	10.18	0.58	15.00	1.51	16.34	1.04	16.88	1.65	19.40	3.79	10.41	0.52
4 mm	2.74	0.26	5.48	0.42	9.41	1.02	10.08	1.00	11.81	1.24	12.27	1.66	5.72	0.37
5 mm	1.09	0.17	3.04	0.34	6.24	0.75	8.23	0.79	7.20	1.48	13.76	3.49	3.51	0.22
6 mm	0.60	0.10	1.69	0.28	3.50	0.55	4.33	0.44	6.34	0.81	5.81	1.50	2.02	0.16
≥7 mm	0.70	0.14	2.67	0.40	5.25	0.97	9.58	1.21	11.12	1.29	15.90	4.27	3.45	0.30
≥3 mm	11.70	0.70	23.07	1.02	39.39	2.38	48.55	3.04	53.34	3.36	67.13	5.57	25.11	1.15
Mexican Americans‡														
<1 mm	10.42	2.05	13.45	4.26	6.29	2.03	11.89	3.74	4.90	2.33	-	-	10.21	1.56
1 mm	46.80	5.09	45.14	4.01	31.63	8.45	41.73	5.12	13.83	3.55	4.80	3.33	41.77	3.67
2 mm	23.62	2.95	23.78	3.40	18.48	3.99	17.69	2.62	27.97	8.16	18.37	7.59	22.46	2.18
3 mm	10.10	2.20	10.11	1.57	15.20	2.84	15.06	3.33	22.61	9.26	35.88	3.17	11.96	1.34
4 mm	5.52	2.25	5.61	1.74	6.41	1.51	5.83	2.68	17.74	6.63	20.47	3.71	6.23	1.44
5 mm	2.24	0.84	1.27	0.56	14.93	6.10	2.88	1.35	1.36	1.06	7.08	2.86	4.45	1.42
6 mm	0.47	0.22	0.25	0.15	2.54	1.41	2.48	0.96	3.82	2.35	12.40	6.73	1.15	0.40
≥7 mm	0.83	0.46	0.40	0.24	4.52	1.99	2.45	2.32	7.77	4.97	0.99	0.93	1.77	0.50
≥3 mm	19.16	4.81	17.64	3.41	43.60	9.27	28.69	5.85	53.31	12.55	76.83	9.32	25.56	3.06

*Standardized by gender and race/ethnicity.

†Standardized by race/ethnicity.

‡Standardized by gender.

Table 4.
Comparison of Prevalence and Extent of Attachment Loss by Gender and Race/Ethnicity

Attachment Loss	Gender*					Race/Ethnicity†							
	Males		Females		P	Non-Hispanic Whites		Non-Hispanic Blacks		P	Mexican Americans		P
	%	S.E.	%	S.E.		%	S.E.	%	S.E.		%	S.E.	
Persons (prevalence)													
≥1 mm	98.99	0.27	98.73	0.33	0.5	98.87	0.26	98.91	0.40	0.9	98.35	0.58	0.4
≥2 mm	83.20	1.43	77.04	1.44	0.0001	78.83	1.45	85.67	1.14	0.0001	83.13	1.67	0.03
≥3 mm	58.73	1.25	47.83	1.35	0.0001	51.15	1.22	64.68	0.98	0.0001	56.27	1.28	0.003
≥4 mm	38.81	1.15	26.97	1.18	0.0001	30.74	1.13	44.82	1.30	0.0001	37.48	0.78	0.0001
≥5 mm	24.36	1.17	15.73	0.96	0.0001	18.14	0.98	31.35	1.06	0.0001	23.17	0.91	0.0001
≥6 mm	15.74	1.03	8.32	0.70	0.0001	10.43	0.78	21.57	0.88	0.0001	14.95	0.67	0.0001
≥7 mm	9.95	0.83	4.89	0.46	0.0001	6.31	0.58	14.30	0.73	0.0001	9.00	0.58	0.001
Teeth (extent)													
<1 mm	15.91	1.29	20.18	1.61		18.62	1.60	14.87	1.27		18.25	1.85	
1 mm	39.16	0.80	45.26	0.92		43.40	0.83	35.79	1.15		39.60	1.17	
2 mm	21.39	1.05	18.63	0.95		19.64	1.03	21.19	1.04		20.65	1.71	
3 mm	10.13	0.33	7.88	0.31		8.62	0.27	11.13	0.48		9.52	0.49	
4 mm	5.56	0.26	4.00	0.24		4.49	0.22	6.32	0.35		5.05	0.24	
5 mm	3.20	0.18	2.05	0.17		2.40	0.15	4.09	0.24		2.98	0.19	
6 mm	2.05	0.16	0.90	0.10		1.32	0.10	2.42	0.14		1.49	0.13	
≥7 mm	2.61	0.30	1.10	0.13		1.51	0.20	4.19	0.36		2.47	0.18	
≥3 mm	23.55	0.76	15.93	0.74	0.0001	18.34	0.72	28.14	0.97	0.0001	21.50	0.71	0.002

*Standardized by age and race/ethnicity.
†Standardized by age and gender.

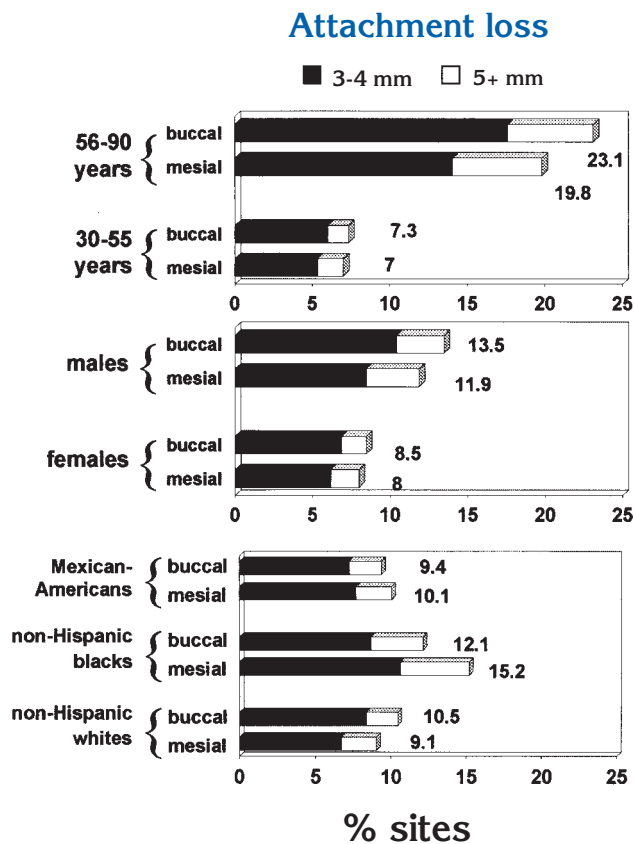


Figure 2.
Percentage of sites by amount of attachment loss, age group, and race/ethnic groups.

prevalences of attachment loss were evident for all tooth types (Fig. 1). Differences in prevalences of site-specific attachment loss between buccal and mesial tooth sites were inconsistently expressed by age, gender, and race-ethnic groups. In the 56 to 90 years old age group as well as for males and whites, the prevalence of attachment loss was higher at buccal sites than mesial sites ($P < 0.01$). On the other hand, the prevalence of attachment loss was higher at mesial sites in blacks ($P < 0.001$) (Fig. 2). The prevalences for buccal and mesial sites were similar for the 30 to 55 year old age group, among females and Mexican Americans.

Probing Depth

The prevalence of ≥ 3 mm probing depth was 63.9%, representing 67.6 million adults, and the extent was 19.6% of teeth per person. Affected persons had, on average, 30.2% affected teeth. The prevalence (Table 5) and extent (Table 6) of probing depth were somewhat consistent in the different age cohorts, but there was a tendency for persons 70 years and older to have lower prevalence than those younger than 70. A comparison by gender and race/ethnicity (Table 7) showed that the prevalence and extent of ≥ 3 mm probing depth were significantly higher in males than in females, and in blacks and Mexican Americans than in whites ($P < 0.001$).

At the tooth-specific level, the prevalence of ≥ 3 mm probing depth was highest in molars, and lowest in incisors and maxillary canines (Fig. 3). The prevalence of probing depth was similar in the age groups 30 to 55 years and 56 to 90 years. Large differences in site-specific prevalences of probing depth

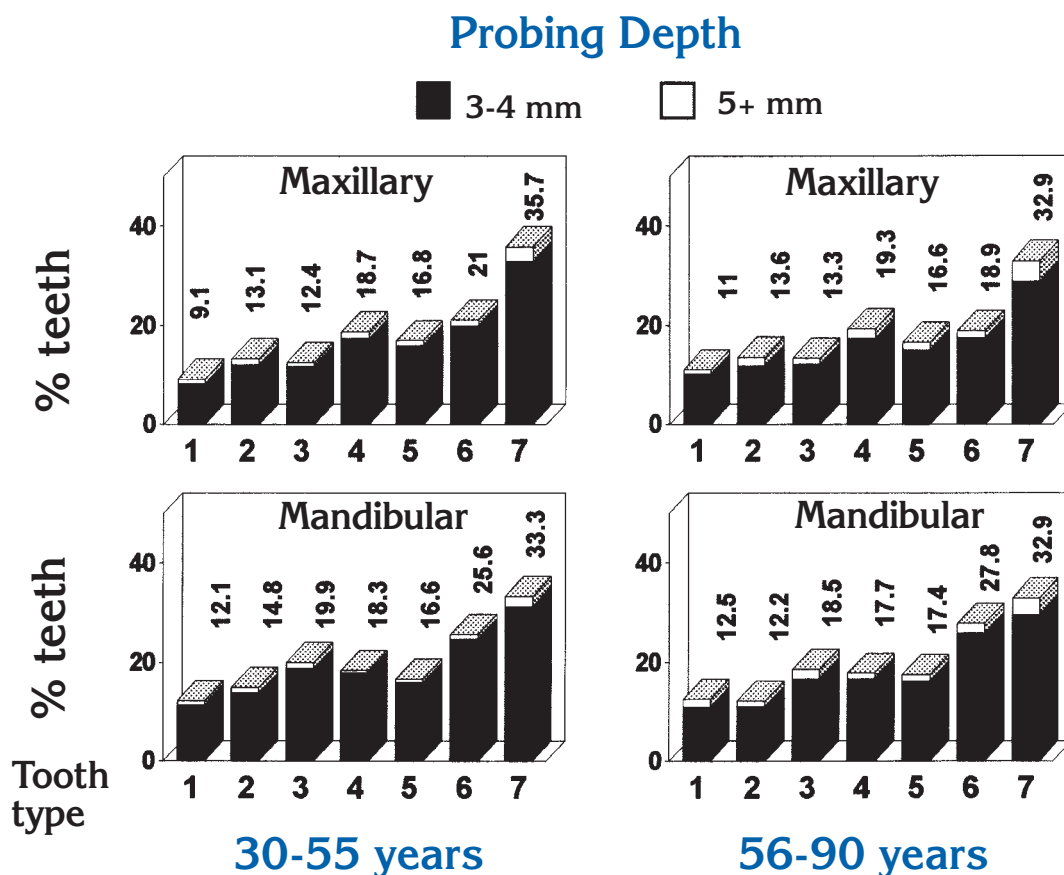


Figure 3. Percentage of teeth by probing depth, tooth type, and age group. Central incisors: 1, second molars: 7.

were observed, with mesial surfaces having higher prevalence than buccal surfaces ($P < 0.0001$) in every age, gender, and race/ethnic group (Fig. 4).

Furcation Involvement

The prevalence of furcation involvement for all age groups was 13.7%, representing 14.5 million adults, and the extent was 6.8% of posterior teeth per person. The prevalence and extent of furcation involvement increased steadily with increasing age, from 5.4% of persons and 2% of teeth in the age group 30 to 39 years, to 37.9% of persons and 22.2% of teeth in the age group 80 to 90 years (Table 8). The prevalence of persons with only one tooth affected was 9.7%, and the prevalence of grade I involvement was 12.8%. There were significantly higher prevalences of persons and higher extent of teeth affected in males than in females ($P < 0.0001$), and in blacks and in Mexican Americans ($P < 0.0001$) than in whites (Table 9). In persons 56 to 90 years old, the highest prevalence of furcation involvement was in the mandibular first molars (Fig. 5).

Classification of Persons by Extent and Severity of Periodontitis

In this sample, 3.1% of persons were classified with advanced periodontitis, representing 3.2 million adults;

9.5% of persons had moderate periodontitis, representing 9.9 million persons; 21.8% of persons had mild periodontitis, representing 22.6 million persons; and 65.5% of persons were without periodontitis, representing 67.9 million persons (Table 10). An additional 258 persons, representing 2.1 million, were not classified because they had too few remaining teeth.

The percentage of persons with periodontitis (mild, moderate, or advanced forms combined) increased with increasing age from 30 to around 70 years and then leveled out between 70 and 90 years of age (Table 10). On the other hand, the percentage of persons with only moderate or advanced periodontitis decreased with increasing age between 75 and 90 years. Persons 75 to 90 years old had, on average, about 11 teeth missing due to dental caries and/or periodontal diseases.

The prevalence and severity of periodontitis were higher in males than in females (Fig. 6), and in blacks and Mexican Americans than in whites (Fig. 7). The prevalence of moderate and advanced periodontitis increased with increasing age from 30 to around 80 years, and decreased thereafter in all 3 race/ethnic groups, with a higher level of decrease in males than in females.

Table 5.
Prevalence of Persons by Probing Depth and Age Cohort

Probing Depth	Age (Years)													
	30-39		40-49		50-59		60-69		70-79		80-90		Total	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
All persons*														
≥1 mm	99.88	0.12	99.99	0.01	100	0	100	0	100	0	100	0	99.96	0.04
≥2 mm	97.29	0.63	96.16	1.05	95.29	0.90	95.17	1.15	92.07	1.36	93.10	1.36	95.91	0.67
≥3 mm	65.74	2.66	65.70	2.06	61.73	2.75	63.87	2.85	55.72	2.75	56.60	2.52	63.92	1.98
≥4 mm	22.16	2.03	21.40	1.82	25.94	2.45	25.43	2.76	25.97	2.54	17.24	2.29	23.11	1.70
≥5 mm	7.18	0.89	8.52	1.05	10.36	1.21	11.70	1.23	11.72	1.56	6.84	1.41	8.86	0.63
≥6 mm	2.68	0.45	3.63	0.64	5.36	0.78	5.57	0.84	5.75	1.06	2.66	0.80	3.88	0.41
≥7 mm	1.27	0.28	1.78	0.37	2.87	0.49	3.10	0.52	2.42	0.65	1.15	0.55	1.93	0.21
Males†														
≥1 mm	99.75	0.25	100	0	100	0	100	0	100	0	100	0	99.91	0.09
≥2 mm	97.81	0.94	96.41	1.28	96.73	1.11	97.07	1.32	92.47	1.96	94.00	1.68	96.74	0.77
≥3 mm	69.74	2.77	70.15	2.51	64.85	3.57	69.98	3.02	60.35	3.65	59.21	3.38	68.38	2.02
≥4 mm	25.63	2.33	27.27	2.57	30.38	3.01	28.79	3.14	30.48	3.37	19.16	2.92	27.39	1.75
≥5 mm	8.26	1.29	11.72	1.60	13.43	1.95	14.68	1.72	15.23	2.46	6.24	1.57	11.17	0.87
≥6 mm	3.60	0.73	5.01	0.98	6.98	1.07	7.04	1.08	7.83	1.79	1.43	0.68	5.10	0.60
≥7 mm	1.56	0.39	2.47	0.62	4.55	0.89	4.69	0.92	3.66	1.16	0.48	0.49	2.71	0.36
Females‡														
≥1 mm	100	0	99.99	0.01	100	0	100	0	100	0	100	0	100	0
≥2 mm	96.81	0.78	95.92	1.14	93.92	1.10	93.37	1.40	91.68	1.59	92.25	1.68	95.12	0.75
≥3 mm	61.94	3.52	61.48	2.72	58.76	3.37	58.05	3.74	51.31	3.09	54.11	3.34	59.69	2.28
≥4 mm	18.85	2.14	15.81	1.64	21.72	2.41	22.21	3.40	21.67	3.20	15.41	3.00	19.03	1.80
≥5 mm	6.14	0.80	5.46	0.99	7.43	1.31	8.87	1.46	8.37	1.64	7.40	1.84	6.65	0.62
≥6 mm	1.80	0.47	2.31	0.52	3.81	0.88	4.18	1.05	3.75	1.03	3.82	1.35	2.70	0.34
≥7 mm	1.00	0.35	1.12	0.36	1.28	0.46	1.59	0.65	1.25	0.53	1.77	0.96	1.18	0.20
Non-Hispanic whites‡														
≥1 mm	99.87	0.13	100	0	100	0	100	0	100	0	100	0	99.95	0.05
≥2 mm	97.47	0.57	96.18	1.01	95.23	0.96	95.10	1.29	91.85	1.43	92.7	1.49	95.93	0.63
≥3 mm	64.74	2.80	64.48	2.23	59.66	2.93	61.29	3.17	52.24	3.10	54.24	2.74	62.24	2.07
≥4 mm	20.16	1.99	19.72	2.02	23.75	2.57	22.20	2.95	22.66	2.80	17.20	2.50	20.99	1.74
≥5 mm	6.03	0.91	7.42	1.15	9.21	1.32	9.57	1.37	9.65	1.70	6.43	1.47	7.63	0.65
≥6 mm	2.42	0.47	2.95	0.67	4.59	0.80	4.27	0.91	4.50	1.08	2.08	0.79	3.29	0.40
≥7 mm	1.26	0.37	1.35	0.38	2.55	0.56	2.23	0.59	1.89	0.68	1.06	0.58	1.66	0.21
Non-Hispanic blacks‡														
≥1 mm	100	0	99.94	0.06	100	0	100	0	100	0	100	0	99.98	0.02
≥2 mm	96.11	1.07	96.09	1.48	95.16	1.94	95.47	1.56	94.94	2.21	94.94	3.23	95.83	1.13
≥3 mm	78.39	2.31	75.68	2.39	71.67	3.46	77.80	3.40	71.22	3.65	67.90	6.56	76.14	2.01
≥4 mm	37.40	2.67	37.90	2.29	39.34	3.89	45.70	3.11	44.87	4.39	16.98	7.25	38.77	2.17
≥5 mm	16.06	1.41	17.89	1.36	18.17	2.39	27.0	2.56	26.86	4.87	9.98	5.42	18.42	1.17
≥6 mm	6.12	1.00	9.60	1.16	10.76	1.77	14.44	1.77	14.89	3.46	7.43	3.87	9.02	0.84
≥7 mm	3.31	0.60	6.46	0.98	5.20	1.35	9.69	1.64	5.40	1.24	2.04	2.08	5.17	0.53
Mexican Americans ‡														
≥1 mm	100	0	100	0	100	0	100	0	100	0	100	0	100	0
≥2 mm	98.97	0.90	99.60	0.29	87.04	5.60	89.28	6.18	86.83	10.44	100	0	95.89	1.51
≥3 mm	75.47	6.27	53.98	8.33	69.12	10.95	67.88	9.39	74.09	9.61	100	0	68.03	4.00
≥4 mm	24.77	6.30	30.49	6.81	28.90	12.3	17.63	9.01	15.81	11.02	11.93	11.13	26.37	4.00
≥5 mm	13.84	5.51	13.70	4.13	17.74	10.94	13.60	7.96	8.18	8.23	-	-	14.50	2.37
≥6 mm	2.54	1.81	0.97	0.47	2.64	1.98	8.65	6.92	7.74	8.19	-	-	2.72	1.12
≥7 mm	2.25	1.78	0.74	0.43	2.64	1.98	1.53	1.28	7.74	8.19	-	-	1.94	0.90

*Standardized by gender and race/ethnicity.

†Standardized by race/ethnicity.

‡Standardized by gender.

Table 6.

Mean Percentage of Teeth by Probing Depth and Age Cohort

Probing Depth	Age (years)													
	30-39		40-49		50-59		60-69		70-79		80-90		Total	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
All persons*														
<1 mm	0.80	0.14	1.02	0.23	1.13	0.23	0.78	0.11	1.04	0.18	0.90	0.20	0.94	0.1
1 mm	38.57	2.40	38.85	2.45	39.42	2.25	37.58	2.58	42.28	2.80	41.95	2.34	39.05	2.19
2 mm	41.56	1.54	39.97	1.62	40.05	1.59	40.87	1.61	37.16	1.72	38.83	1.54	40.40	1.41
3 mm	14.61	0.80	15.19	0.67	13.32	0.72	14.54	0.81	13.22	0.91	13.82	0.98	14.44	0.55
4 mm	3.37	0.41	3.42	0.40	3.98	0.51	3.55	0.56	4.04	0.54	2.89	0.67	3.54	0.36
5 mm	0.70	0.10	0.82	0.08	1.05	0.11	1.47	0.21	1.34	0.22	1.05	0.31	0.92	0.06
6 mm	0.24	0.05	0.32	0.08	0.56	0.11	0.58	0.17	0.54	0.14	0.19	0.08	0.36	0.05
≥7 mm	0.15	0.04	0.42	0.14	0.49	0.09	0.64	0.11	0.37	0.11	0.36	0.20	0.35	0.05
≥3 mm	19.08	1.21	20.17	1.07	19.40	1.19	20.78	1.35	19.52	1.48	18.31	1.33	19.61	0.95
Males†														
<1 mm	0.69	0.26	0.99	0.30	0.90	0.37	0.60	0.17	0.57	0.18	0.64	0.24	0.79	0.15
1 mm	34.24	2.35	34.48	2.63	34.94	2.25	32.78	2.31	39.32	3.12	38.97	2.39	34.72	2.03
2 mm	43.12	1.65	40.21	1.93	42.13	1.87	42.64	1.61	37.45	1.83	40.34	1.82	41.66	1.40
3 mm	16.55	0.85	17.94	1.09	14.24	1.03	16.40	1.00	15.33	1.33	15.39	1.39	16.46	0.63
4 mm	4.00	0.48	4.19	0.46	4.89	0.71	3.87	0.71	4.46	0.79	3.26	0.75	4.18	0.41
5 mm	0.87	0.16	1.13	0.14	1.41	0.20	1.90	0.38	1.55	0.29	1.18	0.41	1.19	0.10
6 mm	0.32	0.08	0.42	0.11	0.69	0.19	0.84	0.32	0.77	0.24	0.14	0.07	0.49	0.08
≥7 mm	0.22	0.06	0.64	0.27	0.80	0.17	0.97	0.20	0.56	0.21	0.08	0.08	0.52	0.09
≥3 mm	21.95	1.30	24.32	1.52	22.03	1.57	23.98	1.57	22.67	2.08	20.05	1.75	22.84	1.03
Females‡														
<1 mm	0.90	0.13	1.04	0.22	1.35	0.26	0.95	0.24	1.50	0.31	1.15	0.33	1.08	0.13
1 mm	42.68	2.73	42.99	2.55	43.69	2.73	42.14	3.14	45.10	3.00	44.78	2.98	43.18	2.44
2 mm	40.08	1.76	39.74	1.62	38.08	1.85	39.20	2.00	36.89	2.02	37.41	2.03	39.21	1.56
3 mm	12.77	0.97	12.58	0.87	12.44	0.88	12.76	1.02	11.22	0.97	12.31	1.18	12.51	0.68
4 mm	2.77	0.43	2.69	0.49	3.11	0.42	3.23	0.61	3.64	0.61	2.55	0.83	2.92	0.35
5 mm	0.54	0.08	0.51	0.12	0.70	0.14	1.06	0.20	1.14	0.27	0.94	0.40	0.67	0.06
6 mm	0.16	0.05	0.23	0.08	0.44	0.12	0.33	0.10	0.32	0.10	0.24	0.12	0.25	0.04
≥7 mm	0.09	0.03	0.20	0.08	0.20	0.07	0.33	0.11	0.20	0.09	0.62	0.37	0.19	0.04
≥3 mm	16.34	1.37	16.22	1.25	16.88	1.34	17.72	1.56	16.52	1.46	16.65	1.66	16.54	1.05
Non-Hispanic whites‡														
<1 mm	0.84	0.14	1.03	0.25	1.12	0.25	0.82	0.13	1.19	0.21	0.97	0.21	0.97	0.12
1 mm	38.94	2.43	40.05	2.56	41.12	2.40	39.40	2.85	44.31	3.07	44.12	2.57	40.15	2.26
2 mm	42.12	1.64	39.94	1.77	40.31	1.69	41.52	1.83	37.35	1.89	38.41	1.76	40.73	1.51
3 mm	14.18	0.83	14.40	0.72	12.16	0.81	13.29	0.90	12.06	0.99	12.19	0.88	13.61	0.56
4 mm	3.03	0.39	3.25	0.42	3.60	0.52	2.92	0.58	3.50	0.55	2.74	0.64	3.20	0.36
5 mm	0.55	0.10	0.72	0.11	0.85	0.13	1.26	0.22	0.93	0.17	1.07	0.36	0.77	0.07
6 mm	0.20	0.05	0.27	0.07	0.41	0.11	0.45	0.18	0.42	0.14	0.13	0.06	0.30	0.05
≥7 mm	0.14	0.04	0.33	0.14	0.43	0.10	0.33	0.10	0.25	0.11	0.37	0.22	0.28	0.05
≥3 mm	18.10	1.21	18.98	1.12	17.45	1.28	18.26	1.42	17.15	1.61	16.50	1.37	18.16	0.96
Non-Hispanic blacks‡														
<1 mm	0.59	0.11	0.69	0.14	0.85	0.26	0.48	0.19	0.09	0.06	0.63	0.60	0.62	0.10
1 mm	32.76	2.62	32.25	2.67	28.73	3.53	25.40	3.09	29.26	3.29	32.62	5.58	31.16	2.49
2 mm	38.06	1.46	38.15	1.54	36.38	2.09	37.09	1.59	37.26	2.12	37.58	4.21	37.72	1.30
3 mm	20.19	0.83	19.74	1.09	22.81	1.68	21.48	1.26	18.86	1.41	24.28	4.81	20.53	0.84
4 mm	5.77	0.66	5.52	0.61	6.35	0.78	8.40	1.08	7.60	1.32	3.00	1.93	6.09	0.54
5 mm	1.76	0.19	1.67	0.20	2.35	0.40	2.95	0.39	4.28	1.35	0.88	0.58	2.04	0.17
6 mm	0.52	0.12	0.76	0.15	1.53	0.42	1.29	0.33	1.49	0.45	0.67	0.48	0.86	0.13
≥7 mm	0.35	0.07	1.22	0.24	0.99	0.27	2.90	0.62	1.16	0.31	0.34	0.35	0.97	0.12
≥3 mm	28.59	1.56	28.91	1.50	34.03	2.48	37.02	2.23	33.39	2.56	29.17	4.43	30.50	1.44
Mexican Americans‡														
<1 mm	0.27	0.13	0.18	0.14	0.91	0.50	0.59	0.18	-	-	-	-	0.39	0.11
1 mm	35.79	3.97	40.98	6.11	40.41	9.11	45.85	5.96	28.54	11.13	43.66	8.43	38.49	3.64
2 mm	42.09	3.11	37.81	3.59	32.94	3.86	37.77	5.99	41.29	8.89	22.41	7.93	38.95	2.22
3 mm	16.88	1.94	13.92	2.79	14.99	3.99	12.85	3.27	24.52	6.47	28.96	2.02	15.65	1.80
4 mm	3.43	1.00	5.18	1.40	6.88	3.11	0.96	0.66	4.13	2.86	4.97	4.64	4.37	1.09
5 mm	1.19	0.50	1.79	0.77	2.43	1.57	0.64	0.47	0.81	0.76	-	-	1.55	0.37
6 mm	0.19	0.14	0.06	0.03	0.25	0.26	1.22	1.11	-	-	-	-	0.25	0.13
≥7 mm	0.17	0.14	0.08	0.05	1.19	1.07	0.12	0.10	0.70	0.74	-	-	0.36	0.22
≥3 mm	21.85	2.85	21.03	4.20	25.74	7.22	15.79	3.58	30.17	8.27	33.93	2.89	22.18	2.68

*Standardized by gender and race/ethnicity.

†Standardized by race/ethnicity.

‡Standardized by gender.

Table 7.

Comparison of Prevalence and Extent of Probing Depth by Gender and Race/Ethnicity

Probing Depth	Gender*					Race/Ethnicity†							
	Males		Females		P	Non-Hispanic Whites		Non-Hispanic Blacks		P	Mexican Americans		
	%	S.E.	%	S.E.		%	S.E.	%	S.E.		%	S.E.	P
Persons (prevalence)													
≥ 1 mm	99.92	0.08	100	0	0.35	99.95	0.05	99.98	0.02	0.5	100	0	0.33
≥ 2 mm	96.68	0.76	95.21	0.74	0.04	95.87	0.69	95.94	1.15	0.95	97.23	0.45	0.09
≥ 3 mm	68.34	1.97	59.77	2.30	0.0001	61.49	2.25	76.50	1.93	0.0001	74.99	1.48	0.0001
≥ 4 mm	27.59	1.72	18.87	1.79	0.0001	20.16	1.88	39.82	2.14	0.0001	32.63	1.40	0.0001
≥ 5 mm	11.35	0.86	6.56	0.62	0.0001	7.17	0.68	19.51	1.20	0.0001	12.88	0.75	0.0001
≥ 6 mm	5.21	0.58	2.64	0.34	0.0001	3.00	0.44	9.88	0.88	0.0001	5.39	0.58	0.001
≥ 7 mm	2.78	0.34	1.15	0.20	0.0006	1.38	0.24	5.63	0.57	0.0001	3.08	0.44	0.002
Teeth (extent)													
<1 mm	0.77	0.14	1.07	0.13		0.98	0.13	0.59	0.10		0.85	0.32	
1 mm	34.72	2.00	43.19	2.44		40.58	2.44	30.03	2.37		33.71	1.36	
2 mm	41.57	1.36	39.28	1.56		40.85	1.59	37.85	1.26		39.35	0.81	
3 mm	16.49	0.62	12.49	0.69		13.25	0.61	20.95	0.83		19.02	0.70	
4 mm	4.21	0.41	2.89	0.35		3.08	0.39	6.33	0.55		4.67	0.25	
5 mm	1.21	0.10	0.66	0.06		0.72	0.07	2.20	0.20		1.59	0.13	
6 mm	0.50	0.08	0.24	0.04		0.29	0.05	0.95	0.13		0.39	0.05	
≥7 mm	0.53	0.09	0.18	0.03		0.25	0.05	1.10	0.13		0.43	0.07	
≥3 mm	22.94	1.02	16.46	1.05	0.0001	17.59	1.05	31.53	1.39	0.0001	26.09	0.94	0.0001

*Standardized by age and race/ethnicity.
 †Standardized by age and gender.

Table 8.

Prevalence and Extent of Furcation Involvement, by the Number of Posterior Teeth Affected and Type of Involvement, and Age Cohort

Furcation Involvement*	Age (Years)													
	30-39		40-49		50-59		60-69		70-79		80-90		Total	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
Persons														
Number of teeth affected														
1	3.87	0.45	8.23	0.68	13.71	1.17	19.38	1.15	22.36	1.98	26.65	2.48	9.71	0.47
2	1.04	0.34	2.63	0.56	4.09	0.65	6.23	1.16	7.55	1.18	9.13	2.05	3.05	0.31
3	0.40	0.21	0.41	0.19	1.11	0.36	1.21	0.38	1.03	0.53	1.98	0.78	0.65	0.10
4	0.10	0.10	0.13	0.11	0.30	0.16	0.75	0.43	0.79	0.30	0.17	0.17	0.24	0.09
Degree of involvement														
Grade I	5.17	0.58	11.12	0.91	17.86	1.35	25.50	1.64	28.57	2.43	34.58	2.95	12.82	0.52
Grade II	0.24	0.16	0.28	0.12	1.35	0.44	2.07	0.56	3.16	0.87	3.35	0.82	0.83	0.18
Total	5.41	0.58	11.39	0.92	19.21	1.35	27.57	1.67	31.73	2.37	37.93	2.78	13.65	0.53
Teeth (percentage per person)														
Grade I	1.78	0.25	5.33	0.57	8.65	0.71	13.71	1.18	16.75	1.60	20.34	1.79	6.26	0.26
Grade II	0.19	0.13	0.21	0.11	0.80	0.26	1.18	0.36	1.93	0.58	1.84	0.63	0.51	0.12
Total	1.97	0.26	5.53	0.58	9.45	0.74	14.89	1.23	18.67	1.53	22.17	1.65	6.78	0.30

*Standardized by gender and race/ethnicity.

Table 9.

Comparison of Prevalence and Extent of Furcation Involvement by Gender and Race/Ethnicity

Attachment Loss	Gender *					Race/Ethnicity†							
	Males		Females		P	Non-Hispanic Whites		Non-Hispanic Blacks		P	Mexican Americans		P
	%	S.E.	%	S.E.		%	S.E.	%	S.E.		%	S.E.	
Persons													
Number of teeth affected													
1	12.00	0.62	8.61	0.56		9.12	0.45	17.22	0.89		12.85	0.70	
2	4.51	0.52	2.05	0.26		2.86	0.35	4.79	0.55		4.99	0.42	
3	0.84	0.19	0.56	0.16		0.56	0.11	1.36	0.32		1.32	0.25	
4	0.46	0.15	0.08	0.07		0.26	0.11	0.18	0.10		0.30	0.07	
Degree of involvement													
Grade I	16.63	0.74	10.62	0.61		12.00	0.49	22.22	1.24		17.89	0.78	
Grade II	1.17	0.27	0.68	0.18		0.81	0.20	1.33	0.29		1.56	0.25	
Total	17.80	0.73	11.30	0.63	0.0001	12.81	0.50	23.55	1.24	0.0001	19.46	0.87	0.0001
Teeth (percentage per person)													
Grade I	8.38	0.44	5.12	0.33		5.81	0.27	12.15	0.79		8.92	0.49	
Grade II	0.77	0.20	0.37	0.11		0.51	0.14	0.83	0.19		0.80	0.13	
Total	9.15	0.48	5.49	0.35	0.0001	6.31	0.31	12.98	0.83	0.0001	9.72	0.54	0.0001

*Standardized by age and race/ethnicity.

†Standardized by age and gender.

Table 10.

Percentages and Estimated Numbers of Individuals 30 to 90 Years Old From NHANES III Survey by Classification According to Extent and Severity of Periodontitis, and Age Group (also shown is the mean tooth loss in the different age groups)

Age (Years)	Periodontal Status								Mean Tooth Loss
	Advanced Periodontitis		Moderate Periodontitis		Mild Periodontitis		No Periodontitis		
	%	No.*	%	No.*	%	No.*	%	No.*	
30-34	1.44	285	3.79	751	17.02	3,376	77.76	15,424	1.49
35-39	2.28	418	7.25	1,330	16.65	3,054	73.83	13,542	2.55
40-44	2.04	343	7.85	1,316	18.04	3,022	72.06	12,071	3.31
45-49	3.84	433	11.04	1,247	22.10	2,495	63.02	7,114	4.82
50-54	4.64	387	10.64	886	23.61	1,966	61.11	5,087	6.09
55-59	3.91	293	14.46	1,082	28.22	2,113	53.41	3,999	7.61
60-64	4.54	293	14.23	919	28.78	1,860	52.46	3,389	7.96
65-69	5.90	341	15.18	878	33.03	1,910	45.89	2,654	8.18
70-74	6.05	276	13.10	597	28.70	1,308	52.15	2,377	9.20
75-79	3.32	81	19.92	487	29.52	722	47.25	1,156	11.02
80-84	3.72	59	17.78	280	31.92	503	46.57	734	10.71
85-90	2.63	19	13.99	101	40.22	291	43.16	313	11.29
Total	3.10	3,228	9.50	9,874	21.80	22,620	65.50	67,860	4.76

*The numbers of individuals (in thousands) represent estimates within a total of 103.6 million adult persons in the U.S population who had 6 or more remaining teeth.

Probing depth

■ 3-4 mm □ 5+ mm

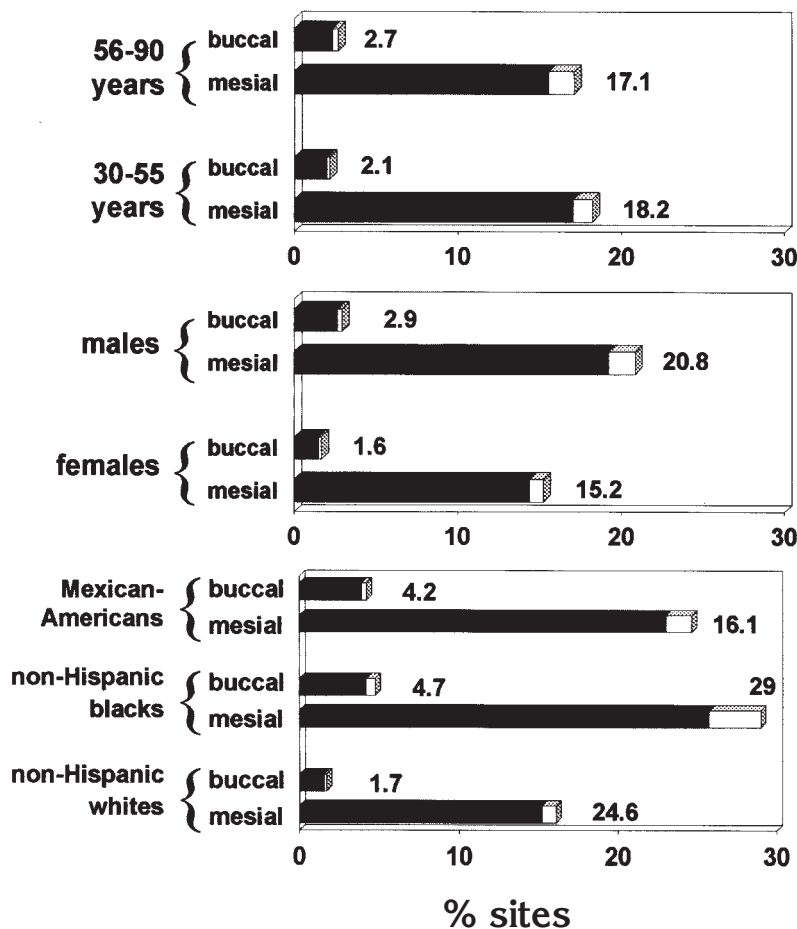


Figure 4.

Percentage of sites by probing depth, age group, gender, and race/ethnic groups.

The overall number of teeth lost increased with age from 1.49 teeth in the age group 30 to 34 years to 11.29 teeth in the age group 85 to 90 years (Table 10). In the age cohort 80 to 90 years, the mean number of teeth lost was 11.7 in males and 11 in females; it was 11 in whites, 13.3 in blacks, and 13 in Mexican Americans.

DISCUSSION

The survey sample used in this study was representative of 105.8 million civilian non-institutionalized Americans aged 30 years and older during 1988 to 1994. The results show that periodontitis affects at least 35% of U.S. dentate adults aged 30 or older. The prevalence of periodontitis was assessed in persons with 6 or more remaining teeth. These results show that 21.8% of persons had mild periodontitis, and 12.6% of persons had moderate or advanced periodontitis. Thus, two-thirds of the affected persons had mild periodontitis and one-third had moderate or severe periodontitis. The prevalence of periodontitis increased considerably with increasing age, and for the whole population, 29% of persons in the age cohort 30 to 54, and 50% of persons 55 to 90 years old had periodontitis. A similar age pattern also occurred in subgroups

Furcation Involvement

■ Grade I □ Grade II

30-55 years

56-90 years

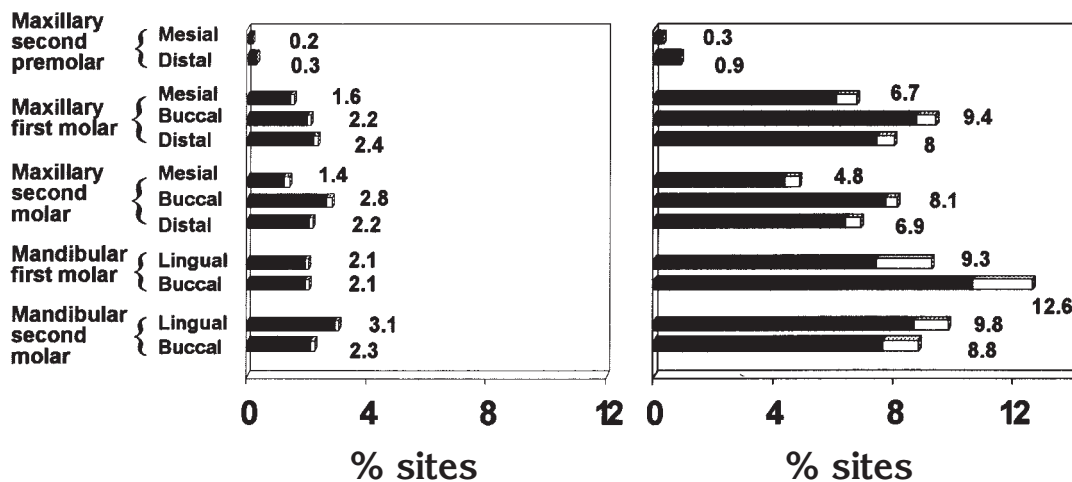
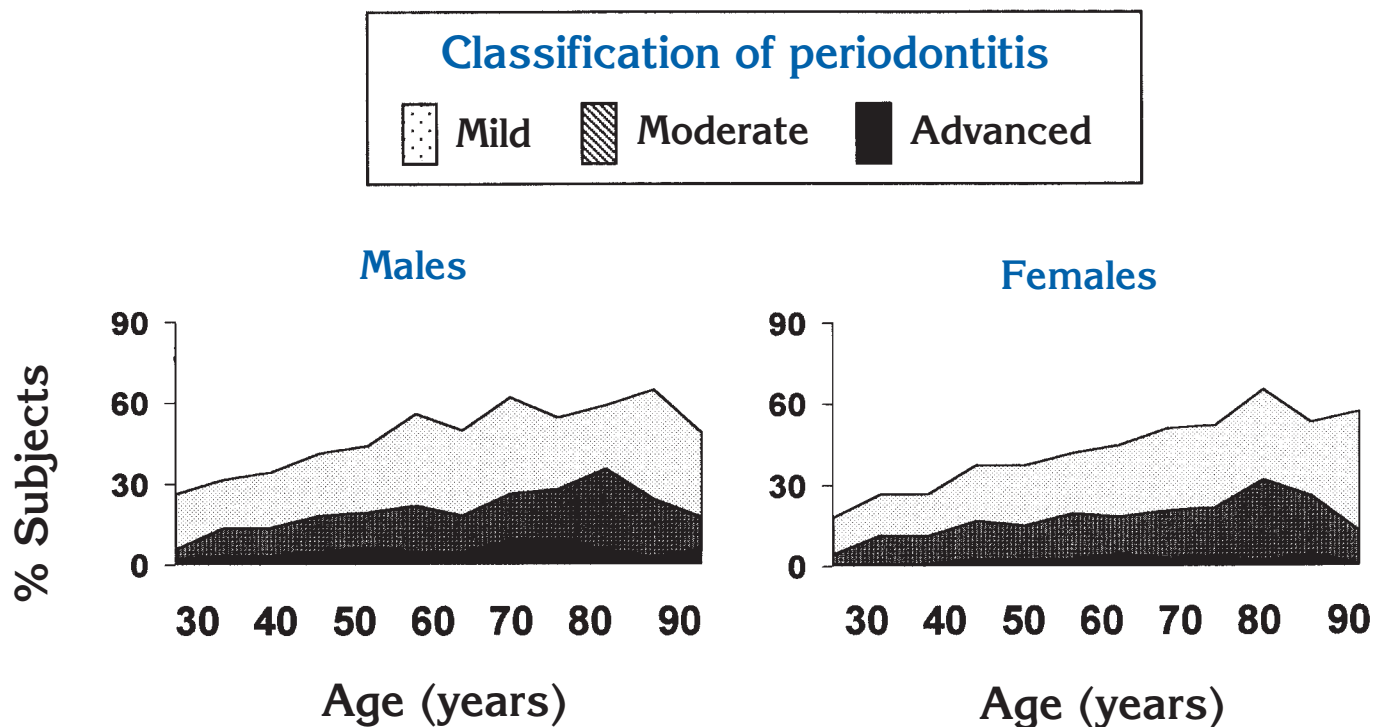


Figure 5.

Percentage of sites with furcation involvement, by age group, tooth type, and surface.

**Figure 6.**

Percentage of individuals with advanced, moderate, or mild periodontitis among U.S. adults examined during 1988 to 1994, by age and gender.

of gender and race/ethnicity. Hence, by age, it increased from 34% to 56% in males and from 23% to 44% in females; by race/ethnicity, it increased from 25% to 47% in whites, from 42% to 70% in blacks, and from 35% to 59% in Mexican Americans. This also shows that periodontitis is consistently more prevalent in males than in females, and in blacks and Mexican Americans than in whites.

The present findings also suggest that moderate and advanced periodontitis decrease in prevalence from about 80 years of age and beyond in all 3 race/ethnic groups studied. However, it should be noted that tooth loss in this age cohort was substantial, with whites, blacks, and Mexican Americans, respectively, having on average 11, 13.3, and 13 teeth lost due to caries and/or periodontitis.

Overall, 53.1% of persons had ≥ 3 mm attachment loss and 63.9% of persons had ≥ 3 mm probing depth in one or more teeth. Moderate to severe levels of attachment loss and probing depth were also prevalent in U.S. adults. Attachment loss and probing depth of ≥ 5 mm, which are manifestations of moderate to advanced periodontal problems, were found in 19.9% and 8.9% of persons, with a significantly higher prevalence in males than females, and in blacks and Mexican Americans than in whites.

The older age groups had more persons and more teeth per person having attachment loss than the younger age groups. In persons 30 to 39 years old, the prevalence of ≥ 5 mm attachment loss was 8% of persons, which increased to 51.4% in persons 80 to 90

years old. However, the relationship between prevalence and extent of probing depth and age was less clear. The prevalence of ≥ 5 mm probing depth reached its peak of 11.7% in the age cohort 60 to 69 years and then decreased to 6.8% in the age cohort 80 to 90 years. The extent of ≥ 5 mm probing depth showed a similar pattern.

It should be noted that the reference points for the assessment of attachment loss and probing depth are the CEJ and the gingival margin, respectively. Since the CEJ is fixed, whereas the gingival margin is not, attachment loss represents a cumulative effect of the overall disease experience and the resulting loss of periodontal support, whereas the probing depth measurement is more variable and also may depend on the magnitude of gingival recession at the site of measurement.

This study showed that the U.S. adult population has a substantial subgroup with periodontal attachment loss. In addition, this population also has a high level of gingival recession.¹² Persons with attachment loss and gingival recession are more likely to experience root caries later.¹³ Coronal caries also is a predisposing factor for periodontal destruction.¹⁴ Although caries and periodontal diseases are the main causes for tooth loss in adults, periodontal diseases were found to be the main reason for tooth extraction in the age group 50 years and older in a U.K. population.¹⁵ These reported findings suggest that in adults, extracted teeth may have had a higher level of destructive periodontal disease than other teeth. Also, an inspection of Table 10 shows that there is an

Classification of periodontitis

Mild
 Moderate
 Advanced

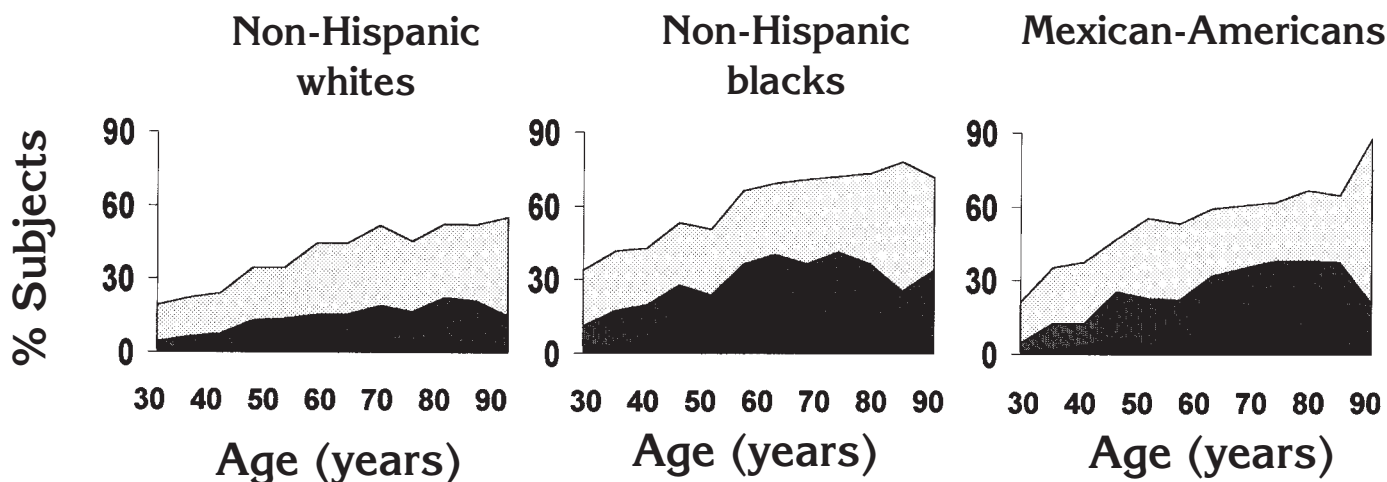


Figure 7. Percentage of individuals with advanced, moderate, or mild periodontitis by age and race/ethnic groups.

increase in the prevalence of mild, moderate, and severe periodontitis separately, but with differing age-specific exit points (lag time) of the increase. This pattern is surely consistent with what one would expect as a consequence of tooth loss in the older age cohorts. Due to the increasing level of difficulty in arresting disease progression at the more severely affected teeth, with or without clinical assistance, the most likely scenario is that tooth loss provides a key factor in the artificial decrease in advanced periodontitis and probing depth prevalences for the oldest age cohorts.

In the 1985 to 1986 NIDR survey of the oral health of United States employed adults and seniors, it was found that 48.6% of persons 35 to 44 years old and 77.3% of those 55 to 64 years old had ≥ 3 mm attachment loss. For ≥ 4 mm probing depth, the corresponding figures were 17.2% and 19.2%, respectively.⁵ In this study, the figures were 48.5% for the 40 to 49 year old cohort and 74.8% for the 60 to 69 year old group having ≥ 3 mm attachment loss, and 21.4% and 25.4% of persons with ≥ 4 mm probing depth, respectively. This shows that the prevalence of ≥ 3 mm attachment loss is similar in the 2 surveys, whereas the prevalence of ≥ 4 mm probing depth is higher in the 1988 to 1994 survey than the prevalence found in the 1985 to 1986 survey. It should be noted that the clinical criteria employed in the 1985 to 1986 survey were similar to those used in the present survey. However, the persons sampled in the 1985 to 1986 survey were representative of the employed and senior population only,

whereas in the NHANES III survey, both employed and unemployed persons were sampled. This may explain the lower prevalence reported in the earlier survey. One possible explanation is that employed persons obtain more regular periodontal prevention and treatment than those not employed. This would be evidenced in the probing depth measurements but not necessarily in the attachment level values.

One other regional survey studied the periodontal health of New England seniors 70 to 96 years old and found that 95% of the persons had ≥ 4 mm attachment loss, and 87% of the persons had ≥ 4 mm probing depth in one or more teeth.¹⁶ This was substantially higher than the findings of the present study, which estimates that 61% and 24% of the persons aged 70 to 90 years have corresponding attachment loss and probing depth. It should be noted that the New England survey used a full-mouth examination and a probing method that assessed the whole circumference of the tooth. Also, the New England seniors may be dissimilar in demographic characteristics from those of seniors examined in this study. It would be of interest to know the effect of examining only 2 sites per tooth for 2 quadrants in the New England seniors.

We recognize that the periodontal assessments made in this study produce underestimates of periodontal disease. The periodontal examination in NHANES III involved a half-mouth examination of 2 randomly selected quadrants, one maxillary and one mandibular. In addition, only 2 sites per tooth were examined, the

mesio-buccal and mid-buccal surfaces. There have been 2 reports investigating the degree of underestimation of the prevalence of periodontal disease by using the partial recording system employed in this study.^{17,18}

In the study by Kingman et al.,¹⁷ two populations having full-mouth examinations, one representing a population with virtually no dental care and one which received optimal dental care, were investigated. In each population, specific partial recording systems were used to produce estimates of the prevalence and severity of periodontal attachment loss. These estimates were then compared with those produced by the corresponding full-mouth assessments. A third population, similar to the one represented in the NHANES III survey, and having full-mouth probing depth measurements, was also included.¹⁷ In this referenced study, the effect of using the mesio-buccal and mid-buccal sites for a random half-mouth system produced prevalence estimates for ≥ 3 mm attachment loss that had a 2% and 20% negative relative bias, and a 4% negative relative bias for ≥ 3 mm probing depth scores.

In the study by Kingman and Albandar,¹⁸ a population with high prevalence of early-onset periodontitis having full-mouth attachment level and probing depth measurements at 6 sites per tooth was used to assess the relative bias of the mesio-buccal and mid-buccal random, half-mouth partial recording protocol. There was a 26.3% negative relative bias for ≥ 3 mm attachment level and a 32.3% negative relative bias for ≥ 3 mm probing depth scores. Thus, the degree to which disease is underestimated can vary considerably, depending on the underlying prevalence of disease in the population, the level of dental care and treatment, and also the age distribution of the population.

Furthermore, tooth loss was substantial in this population, particularly in the older age cohorts, and this may have contributed to a reduction in the estimated prevalence and severity of periodontitis and other periodontal parameters.

Persons with cardiovascular problems or other medical conditions that may require antibiotics coverage before a periodontal examination were not included in this survey. There are data suggesting that these persons may have higher prevalence and extent of periodontal diseases than healthy persons.² Hence, excluding these persons also may have caused an underestimation of the assessed level of destructive periodontal disease in the U.S. adult population.

The NHANES III was based on a complex, multi-stage probability sample design. The survey was completed over 6 years in two 3-year phases. Several aspects of the survey design must be taken into account when reporting the results and in data analysis, including the sample weights and the complex survey design used. It is also important to note that individual phase estimates of parameters assessed in the

NHANES III survey may be highly variable due to changes in sampling methods between the 2 phases.⁸ One example that clearly illustrates this point is the finding of a lower prevalence of persons with deep (≥ 4 mm) probing depth in phase 2 than in phase 1 of NHANES III. At this time, there is no valid statistical test for examining differences between phase 1 and phase 2.⁸ Therefore, it is difficult to evaluate whether this or other differences between the 2 phase estimates are real, or are due to methodological differences or examiner bias. However, the study by Kingman et al.¹⁹ evaluating examiner reliability in NHANES III shows that all 3 examiners who conducted most survey examinations scored consistently with the reference examiner. These results suggest that differences among the examiners due to examiner unreliability can be ruled out. The National Center for Health Statistics recommends using combined estimates from both phases 1 and 2 of the NHANES III in the computation of national estimates.

It should be emphasized also that the present estimates represent national averages. Unquestionably, there are regional differences that may produce varying prevalence values above and below these averages. In the present study, thresholds of attachment loss and probing depth ranging from ≥ 1 mm to ≥ 7 mm were used for reporting the prevalence of these indicators of periodontal disease, and thresholds of < 1 mm to ≥ 7 mm were used for extent. We feel that this detailed presentation of the data will make it feasible to compare the present findings with findings from other populations based on regional or national samples.

This is the first study that uses national representative data to assess the prevalence and extent of furcation involvement. Furcation involvement is a sign of extensive loss of periodontal supporting tissue and, together with increased probing depth, was used in this study as a criterion for classification of periodontitis. As was expected, the results show a strong correlation between the prevalence and extent of furcation involvement and age. Also, there were higher prevalences and extent of furcation involvement in males than females, and in blacks and Mexican Americans than whites. This is consistent with the trend seen for attachment loss in this adult population.

The estimates of periodontal disease outcomes reported in this study can be useful for the study of oral health status of the U.S. adult population. We estimate that in persons 30 years and older, there are approximately 56.2 and 67.6 million persons who, on average, have about a third of their remaining teeth showing ≥ 3 mm attachment loss and probing depth, respectively. It is also estimated that there are about 21 million persons with ≥ 5 mm attachment loss, and 36 million persons with destructive periodontitis.

These findings are important to appreciate the level and characteristics of destructive periodontitis, and can be

valuable for planning resources for the prevention and management of the disease. These data can be used to identify subpopulations who experience rather high levels of disease, or present peculiar disease profiles. These data, coupled with other data available in the NHANES III database, can be used to investigate the possible associations between specific oral health conditions and general systemic health. In addition, the reported findings provide another time point profile of the periodontal status of the U.S. adult population, and as such, will be used to monitor changes and trends in periodontal health in U.S. adults.

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