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A Clinical Validation of Self-Reported Periodontitis Among Participants in the Black Women's Health Study

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Abstract

Background—There is a paucity of data on the validity of self-report of periodontal disease in African Americans. The Black Women's Health Study (BWHS), a United States national cohort study of 59,000 black women followed via mailed questionnaires since 1995, offered the opportunity to clinically validate self-reported periodontitis among a sample of participants.

Methods—Oral health questionnaires were sent to study participants residing in Massachusetts. Respondents living in the Boston metro area were invited for clinical examination. Self-reports were compared with clinical data obtained from the 77 women (mean age: 59 years) who were examined. The authors examined the predictive ability of individual and combined questionnaire items with respect to clinical periodontal disease severity. Validation parameters were calculated for each question, and receiver operating characteristic statistics were generated to compare questionnaire items.

Results—Periodontitis prevalence in the validation sample was 24% for severe periodontitis and 61% for moderate disease. Performance of individual questionnaire items with respect to predicting periodontitis was better for severe compared with moderate disease. Combinations of questionnaire items improved the predictive ability with respect to severe disease beyond that of individual questionnaire items.

Conclusions—Prevalence of severe periodontitis was similar to other age-comparable populations, without regard for race or sex, whereas prevalence of total periodontitis (moderate and severe) among women of similar age and/or race was much higher. Predictive ability of questionnaire items assessed in the BWHS was similar to that in other studies.

Keywords

Epidemiology; minority health; periodontitis; self report; validation studies as topic; women's health

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Self-reported measures of oral health provide a cost-effective means to monitor the oral health of populations over time.[1] Such self-reports have been successfully incorporated into existing United States national cross-sectional surveillance programs, including the National Health and Nutrition Examination Survey (NHANES)[2] and the Behavioral Risk Factor Surveillance Study.[3] However, validated self-report measures have been used to study oral health outcomes of adults longitudinally in relatively few large population-based cohorts.[4,5] Expanding the implementation of self-report measures requires evaluation across varied populations.

Over the past decade, extensive work has been done to clinically validate self-reported items regarding periodontal disease specifically.[6,7] These efforts have provided valuable data on the clinical validity of a variety of self-reported measures of periodontal disease, leading to measure refinement, as well as contributing to establishing periodontitis case definitions for surveillance.[8,9] However, there remains a paucity of data on the validity of periodontal self-report measures in African Americans. As the prevalence and severity of periodontal disease in the United States,[10,11] as well as of tooth loss and edentulism,[12] are greater in African Americans compared with other groups, there is a need to validate such measures in this higher risk population group. Cost-effective and larger-scale monitoring of the oral health of racial/ethnic minority populations is essential to addressing oral health disparities.

The Black Women's Health Study (BWHS) is a United States cohort study of 59,000 black women who have been followed since 1995.[13–15] It provides a unique opportunity to study oral health outcomes via self-report in black women.[14] A validation study of oral health self-report measures in this cohort was conducted. The primary objective of the current study was to clinically validate previously developed self-report measures of periodontitis among a sample of BWHS participants residing in the state of Massachusetts. Specifically, the authors aimed to evaluate eight self-report items previously developed under the Periodontal Disease Surveillance Initiative,[16] individually and in combination, with respect to predicting periodontal disease severity.

MATERIALS AND METHODS

Human participant research approvals were obtained from the Boston University Medical Campus Institutional Review Board, Boston, Massachusetts, and written informed consent was obtained from all study participants.

BWHS

In 1995, 59,000 black women enrolled in the BWHS by responding to a mailed health questionnaire.[13] Questionnaires were mailed to subscriber lists of *Essence* magazine, members of selected black women's professional organizations, and friends and relatives of early respondents. At baseline, the women were aged 21 to 69 years (median age: 38 years), 97% had completed high school, and 94% reported having health insurance. Biennial postal and web questionnaires are used to update exposure and outcome information, including medical and reproductive history, smoking and alcohol use, physical activity, anthropometric measures (e.g., height, weight), use of selected medications, diet, and use of medical care.

The follow-up of BWHS participants has been successful: over nine follow-up cycles, follow-up has been complete for 87% of potential person years. In 2014, when participants for the present oral health validation study were drawn from among Massachusetts participants, the mean age of BWHS participants was 59 years.

Oral Health Validation Study

Among BWHS participants residing in the state of Massachusetts, an internal validation study was conducted using a two-stage sampling process.

Oral health questionnaires were mailed to all active BWHS participants currently residing in Massachusetts (n = 699), the vast majority of whom resided in the Boston Metropolitan Area. The response rate for completed questionnaires was 69% (484 females, aged 40 to 88 years; mean age: 59.3 years).

Clinical sample—Invitation letters to take part in the clinical validation study were sent to participants who returned completed questionnaires between November 2014 and May 2015, lived within commuting distance to the dental clinic, and reported having at least eight natural teeth present (n = 169). Those who attended the clinic for examination were reimbursed for their time and travel expenses (n = 77). A flowchart of participant recruitment can be found in supplementary Figure 1 in online *Journal of Periodontology*.

Oral Health Questionnaire

Candidate items for the oral health questionnaire were selected based on items previously administered in national samples, including the Behavioral Risk Factor Surveillance System[17] and NHANES,[6] other longitudinal cohorts such as the Health Professionals Follow-up Study[4] and the Veterans Affairs Dental Longitudinal Study,[5] as well as previously validated items and scales such as Oral Health Quality of Life,[18] Oral Health Impact Profile,[19] and Index of Dental Anxiety and Fear.[20] The final questionnaire included 23 items and/or scales evaluating: 1) domains of dental care needs; 2) utilization and insurance; 3) periodontal and gingival health; 4) oral health practices; 5) fixed and removable replacements; 6) dental fears and anxiety; and 7) oral health–related quality of life (see supplementary Appendix 1 in online *Journal of Periodontology*).

Self-Reported Periodontal Measures

The questionnaire included eight self-report items that were developed as part of the US Centers for Disease Control and Prevention Periodontal Disease Surveillance Project, in collaboration with the American Academy of Periodontology (CDC-AAP),[16,21] to measure periodontal health in national samples, such as NHANES. These eight items were included, verbatim, as previously described elsewhere.[7] Additionally, a question was included that has previously been included on BWHS questionnaires: *"Has a dentist or dental hygienist ever told you that you had periodontal or gum disease?"*

The following BWHS questionnaire data were used in analyses: 1) age of participant; 2) years of education; 3) marital status; 4) smoking status; and 5) history of type 2 diabetes mellitus (DM).

Examination Procedures

All participants in the clinical sample (n = 77) were seen at the Center for Clinical Research at the Henry M. Goldman School of Dental Medicine, Boston University, Boston, Massachusetts. A single, trained dentist examiner (NBG) conducted all dental examinations after a standardized examination protocol based on the NHANES oral health examination. Clinical assessments were made of periodontal health status, including: 1) tooth mobility; 2) presence of caries; 3) restorations and fixed replacements; and 4) removable denture status and fit. Data were recorded directly onto paper forms by a trained study recorder (Rachelann Tripp, Boston University, Boston, Massachusetts). Participants (n = 2) were excluded from the periodontal examination if they had an artificial joint and had not taken their antibiotic premedication prophylaxis prior to periodontal probing as recommended by their physician.

Periodontal Measures

Using a color-coded periodontal probe, graduated at 2, 4, 6, 8, 10, and 12 mm,[§] six sites were examined on each tooth: distal buccal, mid buccal, mesial buccal, distal lingual, mid lingual, and mesial lingual. Periodontal probing depth (PD) and gingival recession were measured to the nearest millimeter (mm). Bleeding on probing was assessed and documented as present or absent. A post hoc calculation of clinical attachment loss (AL) was conducted by summing the millimeters of PD and the millimeters of recession, when the gingival crest was below the cementoenamel junction (CEJ). When the gingival crest was above the CEJ, the distance from CEJ to gingival crest was subtracted from PD to arrive at AL.

Periodontitis Case Definition

The 2007 CDC-AAP definitions were applied for severe, moderate, and mild/no periodontitis.[9] Severe periodontitis was defined as at least two interproximal sites with ≥6 mm of AL (not on the same tooth) and at least one interproximal site with ≥5 mm of PD. Moderate periodontitis was defined as at least two interproximal sites with ≥4 mm of AL (not on the same tooth) or at least two interproximal sites with ≥5 mm of PD. Mild to no periodontitis was defined as anything not meeting the above-defined threshold of moderate periodontitis. In addition to case definitions, mean PD and mean AL were calculated by taking the average of all four interproximal measurements obtained in the mouth. Third molars were excluded from all post hoc assessments of periodontal disease.

Statistical Analyses

Participant demographics and responses to questionnaire items were compared across the questionnaire and validation samples using percentages and means (± SD). Dental characteristics and questionnaire responses of the clinical sample were compared according to the CDC-AAP periodontitis case definitions. “Don’t know” responses were excluded from evaluation. Validation parameters for severe and moderate periodontitis were calculated for each of the eight questionnaire items recommended by the CDC-AAP by using the clinical examination as the gold standard. The four classification parameters: 1)

[§]CP-2, Hu-Friedy, Chicago, IL

sensitivity; 2) specificity; 3) positive predictive values; and 4) negative predictive values, were calculated with exact binomial 95% confidence intervals.

Multiple question scales were created by combining questionnaire items into single variables for evaluation and comparison by receiver operating characteristic (ROC) curves. Variables reflecting question scales included combinations based on the CDC-AAP recommended items, subsets of those items that have been previously tested,[6] as well as scales including individual questionnaire items with optimal sensitivity and specificity and items reflecting periodontal disease history and periodontal disease burden. Specifically, items related to receipt of periodontitis treatment, tooth mobility, and bone loss were considered reflective of periodontal history, whereas perceptions of gum disease, self-rating of oral health, and tooth appearance were considered reflective of current disease burden. In addition, model selection methods were used to create scale variables comprised of combinations of items that were maintained in the predictive model when assessed individually. ROC curves and the associated statistics were generated using a logistic regression model with clinically determined periodontal status as the dependent variable and the question scale as the primary independent variable. Models evaluating question scale variables were also adjusted for the following covariates: 1) age; 2) number of teeth; 3) dental insurance status; 4) report of current dental treatment needs; 5) smoking status; and 6) diabetic status. The area under the curve (AUC) and diagnostic odds ratio (OR) for the question scale variable were compared across models. A statistical software package was used for all analyses.[‖]

RESULTS

Study Participants

Table 1 displays characteristics of BWHS participants in Massachusetts who completed the oral health questionnaire (n = 484), participants invited to attend the clinic (n = 169), and participants who attended the dental clinic (n = 77). The groups did not differ appreciably in age (mean age: 59 years), smoking status, and history of DM. Women who attended the dental clinic had higher levels of educational attainment. The three groups were similar in self-reported tooth count, time since last dental cleaning, whether they reported being in need of dental care, and whether they had partial or full dental insurance. However, those in the clinic sample were more likely to have accessed dental services and to report dental care needs that they could not afford to address within the past 12 months.

Self-Reported Periodontal Health

Data on self-reported periodontal health from the CDC-AAP recommended items are presented in Table 2. Frequencies of “don’t know” or “refused” responses were very low, resulting in a >97% response rate across all items. The majority of women rated their oral health as “good” or better. Nearly half of the total sample (46%) reported receipt of treatment for “gum disease” and nearly one-third (28%) reported having been told by a dental professional that they had bone loss around their teeth. Compared with the questionnaire sample, the clinical validation sample reported slightly higher rates of weekly

[‖]SAS 9.3, SAS Institute, Cary, NC

dental floss use and affirmative responses regarding periodontal health indicators with the exception of noticing that a tooth did not look right.

Clinical Periodontal Disease Status

Table 3 displays results of the periodontal exam. Among those who received exams (n = 75), 24% of women were found to have severe periodontitis, 61% had moderate disease, and 15% had mild/none. Women with severe disease were older, more likely to be current smokers, less educated, had a higher proportion of mobile teeth, and presented with higher mean PD and mean AL. They were also less likely to have full or partial dental insurance, to report having attended a dental clinic for preventive or treatment services within the last year, and more likely to report fears or anxiety associated with visits to the dentist. Compared with moderate and mild cases of periodontitis, severe cases of disease were more likely to report weekly use of mouthwash or dental rinse and answer affirmatively to all of the CDC-AAP self-report questions (yes/no) regarding periodontal health (Table 4). Moderate cases were also more likely to report that they think they might have gum disease, receipt of treatment for gum disease, tooth mobility, having been told they have bone loss, and noticed a tooth not looking right, compared with those with mild or no periodontitis.

Validation Parameters

Table 5 displays validation parameters for the evaluated periodontal self-report items. Among those with clinically determined severe periodontal disease, questions related to receipt of periodontal treatment (CDC-AAP 3) or communication with a dental professional regarding periodontal disease status (BWHS) were associated with higher estimates of both sensitivity and specificity. Questions related to self-perceptions or self-assessments of periodontal health (CDC-AAP 1, 4, and 6) were associated with higher estimates of specificity. The positive predictive value (PPV) was generally low for all questions, and most had high negative predictive values (NPVs). When moderate cases of periodontal disease were combined with severe cases, estimates of sensitivity decreased and were below 50% for all questions, aside from reports of periodontal treatment (56%) and self-rated oral health (84%). However, estimates of specificity were improved for all items, aside from mouthwash, compared with only severe cases. In addition to the periodontal disease self-report questions (e.g., CDC-AAP items), reports of current dental treatment needs produced higher estimates of both sensitivity (65%) and specificity (67%) among severe cases, compared with many of the CDC-AAP recommended items (data not shown).

ROC Curve Analyses

Question scale variables and the associated AUC and OR for each scale used to predict severe periodontitis are presented in Table 6. Combining questions into a scale resulted in improved estimates of all validation parameters. Models adjusted for participant characteristics generally resulted in improved AUC values. The adjusted model containing the eight CDC-AAP recommended questionnaire items scale resulted in an adjusted AUC value of 0.79. Scale variables representing subsets of the CDC-AAP questions based on periodontal health domains (e.g., periodontal disease history and periodontal disease burden) did not result in better prediction (see Table 6; models 6 and 7). However, question subsets that were comprised based on results of model selection methods using individual

questionnaire items resulted in improved predictions, above that of the adjusted CDC-AAP scale, which included all eight items. For example, when individual questionnaire items were ranked according to prediction abilities in a logistic model and only the top four were included (e.g., Table 6; model 8), outcome prediction was improved beyond including all eight items in the scale.

DISCUSSION

In the present study, the authors aimed to validate self-reported oral health items as indicators of clinical periodontitis in a sample of participants from the BWHS cohort. Specifically, the eight recommended CDC-AAP items were evaluated, both individually and in combination. Performance of individual questionnaire items, with respect to predicting periodontitis, was generally better for severe compared with moderate disease. Questions related to receipt of treatment and dental care visits yielded higher estimates of sensitivity and specificity. For example, reports of periodontal treatment (CDC-AAP item 3) and diagnosis by a dental professional (BWHS item) were associated with sensitivity and specificity estimates that both exceeded 50%. Validation parameters for individual questionnaire items using the CDC-AAP case definition have not been reported on in the research literature, thereby limiting the ability of the authors to compare the performance of individual questionnaire items in the current study population with others. However, the predictive ability of the questionnaire items in combination was comparable with other populations based on ROC statistics.[6] For example, using the same case definition, Eke et al.[6] reported an ROC value for a fully adjusted model containing the CDC-AAP recommended items of 0.81, similar to the finding in this study of 0.79. However, predictions based on question subsets varied, highlighting the need for population-specific validation studies.

Many validation studies have been conducted to evaluate the performance of self-report items, particularly related to periodontal disease,[6,21–25] and results have been promising with respect to accurately predicting presence or absence of severe periodontal disease. The work presented here is the first to focus exclusively on African American women. Estimates of severe periodontitis in the current study were within the range of prevalence estimates observed among other age-comparable populations but higher compared with populations that were black, non-Hispanic, and/or female.[25–27] Total periodontitis prevalence in the present population was higher than prevalence estimates observed in other populations based on comparable age, race, and/or sex. Specifically, total periodontitis prevalence was greater among the current population (85%) compared with NHANES estimates among non-Hispanic blacks who were 50 to 64 years of age (73%)[27] and non-Hispanic black women of all ages (47%).[26]

The predictive ability of the eight recommended CDC-AAP questionnaire items and for a single question included in the BWHS questionnaire was comparable with other populations based on ROC statistics. However, the BWHS sample was older and thus had a higher prevalence of severe periodontitis compared with studies reporting ROC statistics among more age-inclusive populations. The ability of the authors to make more detailed comparisons with data from other populations is further limited given the minimal reporting

in the literature of validation parameters for single questionnaire items and the variation in case definitions used. Furthermore, population-specific factors such as socioeconomic position and dental care behaviors will, in part, determine the accuracy and variability in responses to these questionnaire items across populations. In the present study population, reports of dental care utilization, dental care needs, and dental insurance were high. Therefore, it is not surprising that questionnaire items related to receipt of treatment and interactions with dental care providers yielded higher estimates of sensitivity, compared with questions reflecting self-perceptions. For example, it may be reasonable to assume that the relatively poorer performance of the item, “Do you think you might have gum disease?” in this population compared with other reported studies may reflect self-perceptions of active disease as opposed to treated disease or disease currently undergoing treatment. Among severe cases of disease in the current clinical sample, 78% reported receipt of treatment for periodontal disease, but of those only 33% reported that they think they might have gum disease. Similarly, 80% of severe cases reported receipt of treatment for periodontal disease and concurrently reported that they had *ever* been told by a dentist or dental professional that they had gum disease. This potential point of confusion with respect to current disease status for participants who report receipt of periodontal treatment was also identified and reported on during the initial cognitive testing of these questions.[28]

Based on ROC analyses in the current study, it may not be necessary to administer all eight CDC-AAP recommended items to achieve optimal prediction. Specifically, removing questions related to flossing and use of mouthwash (which performed poorly in the present study population) did not appear to influence the crude or adjusted AUC values. Models based on selection methods used in other populations[4] performed similarly to models using variable selection methods in the present population. When planning for additional data collection within a population, such as the BWHS, if only a limited set of questions can be implemented into existing data collection efforts for reasons of feasibility, selection of question subsets may be aided by an understanding of the population characteristics as discussed above.

Evaluation of these self-report questionnaire items was limited as a result of the validation sample size, despite the relatively high prevalence of severe cases of periodontal disease. The sample of women studied in the dental clinic comprised volunteers from one geographic area; although they were similar to BWHS participants overall in several important characteristics, they differed in others, and the possibility of selection bias cannot be ruled out. Future work would benefit from larger samples. In addition, development of self-report items that capture interactions with dental care services related to periodontal health and history in greater detail may be of benefit.

CONCLUSION

The current study provides needed data on the validity of previously developed self-report items in identifying clinical disease among a population with demonstrated oral health disparities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Basic Characteristics of Participants Across Study Samples

	Clinic Invitation (n = 169)		
	Oral Health Questionnaire (n = 484)	**Non-Responders (n = 92)**	**Responders: Validation Sample (n = 77)**
Sample characteristics			
Current mean age (years)	59.3	56.7	59.3
Education (% ≥college graduate)	64.0	60.9	72.7
Current smoker (%)	8.3	11	9.5
DM diagnosis (%)	18.4	14.1	23.4
Dental status self-report			
Self-reported tooth count (mean)	23.4	25.2	24.8
Time since last dental visit for any reason <12 months (%)	80.9	73.9	88.3
Time since last dental cleaning <12 months (%)	78.8	72.8	84.4
Currently in need of dental treatment (%)	35.9	44.0	39.2
Has partial or full dental insurance (%)	82.2	87.0	82.9
Unable to afford needed dental care in the last 12 months (%)	17.3	18.9	22.4

Table 2

Questionnaire Responses to CDC-AAP Recommended Items[5,14,21] Across Participant Samples

Periodontal Health Questions	Clinic Invitation (n = 169)		
	Oral Health Questionnaire (n = 484)	Non-Responders (n = 92)	Responders: Validation Sample (n = 77)
1. Do you think you might have gum disease? (%)			
Yes	17.8	12.0	18.2
2. Overall, how would you rate the health of your teeth and gums? (%)			
Excellent	16.2	16.3	18.2
Very good	33.3	33.7	29.9
Good	30.6	33.7	39.0
Fair	15.5	15.2	11.7
Poor	4.4	1.1	1.3
3. Have you ever had treatment for gum disease, such as scaling and root planing, sometimes called “deep” cleaning? (%)			
Yes	45.8	40.2	49.4
4. Have you ever had any teeth become loose on their own, without an injury? (%)			
Yes	13.1	4.4	15.6
5. Have you ever been told by a dental professional that you lost bone around your teeth? (%)			
Yes	28.1	20.9	33.8
6. During the past 3 months, have you noticed a tooth that doesn’t look right? (%)			
Yes	12.0	12.1	8.0
7. Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use dental floss or any other device to clean between your teeth? (%)			
0	10.2	10.9	3.9
1 to 7	89.8	89.1	96.1
8. Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use mouthwash or other dental rinse product that you use to treat dental disease or dental problems? (%)			
0	36.1	30.4	41.6
1 to 7	63.9	69.6	58.4

Table 3

Participant Characteristics and Self-Reported Dental Health According to Periodontitis Case Definition

	Severe (n = 18)	Moderate (n = 46)	Mild/None (n = 11)
Participant Characteristics			
Current mean age (minimum, maximum)	61.1 (45 to 78)	59.2 (43 to 73)	56 (47 to 66)
Education (% ≥college graduate)	66.7	71.7	90.9
Current smoker (%)	26.7	6.5	0
Diabetic diagnosis (%)	16.7	28.3	18.2
Dental status			
Number of teeth present (mean)	22.8	23.1	25.7
Number of decayed, missing, filled, treated teeth (mean)	17.2	15.4	15.4
Proportion of teeth with mobility (%)	16.1	7.0	3.0
Mean PD	2.8	2.3	2.1
Mean AL	2.9	2.4	2.1
Self-reported dental health			
Self-reported tooth count (mean)	24.2	24.6	26.8
<12 months since last dental visit for any reason (%)	72.2	91.3	100
<12 months since last dental cleaning (%)	55.6	91.3	100
Currently in need of dental treatment (%)	61.1	39.8	9.1
Unable to afford dental care in past 12 months (%)	38.9	22.2	0
Has partial or full dental insurance (%)	66.7	86.7	90.9
Oral health-related quality of life (mean)	22.6	16.9	9.5
Dental fears and anxiety (IDAF_4C) (mean)	2.4	1.4	1.1
Stimuli (IDAS) (mean)	2.5	1.7	1.1

Table 4

Self-Reported Periodontal and Clinical Status (%) According to Periodontitis Case Definition

Periodontal Health Questions	Severe (n = 18)	Moderate (n = 46)	Mild/None (n = 11)
1. Do you think you might have gum disease?			
Yes	27.8	17.4	0
2. Overall, how would you rate the health of your teeth and gums?			
Excellent/very good	33.3	47.8	81.8
Good	33.3	43.5	18.2
Fair/poor	33.3	8.7	0
3. Have you ever had treatment for gum disease, such as scaling and root planing, sometimes called “deep” cleaning?			
Yes	77.8	43.5	18.2
4. Have you ever had any teeth become loose on their own, without an injury?			
Yes	22.2	15.2	9.1
5. Have you ever been told by a dental professional that you lost bone around your teeth?			
Yes	50.0	34.8	0
6. During the past 3 months, have you noticed a tooth that doesn’t look right?			
Yes	11.8	8.9	0
7. Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use dental floss or any other device to clean between your teeth?			
0	0	6.5	0
1 to 7	100	93.5	100
8. Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use mouthwash or other dental rinse product that you use to treat dental disease or dental problems?			
0	33.3	43.5	54.6
1 to 7	66.7	56.5	45.4

Table 5

Validation Parameters for Periodontal Self-Report Items According to Disease Status

	Severe Disease (n = 18) (95% CI)				Moderate and Severe Disease (n = 64) (95% CI)			
Periodontal Self-Report Measures	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Gum disease	0.33 (0.12 to 0.62)	0.84 (0.71 to 0.93)	0.38 (0.14 to 0.68)	0.81 (0.67 to 0.90)	0.24 (0.1 3 to 0.37)	1 (0.69 to 1.0)	1 (0.75 to 1.0)	0.19 (0.10 to 0.33)
Self-rating	0.67 (0.41 to 0.87)	0.07 (0.02 to 0.17)	0.18 (0.10 to 0.30)	0.40 (0.12 to 0.74)	0.84 (0.74 to 0.92)	1 (0.72 to 1.0)	0.83 (0.72 to 0.91)	1 (0.69 to 1.0)
Treatment	0.78 (0.52 to 0.94)	0.59 (0.45 to 0.72)	0.39 (0.23 to 0.57)	0.89 (0.74 to 0.97)	0.56 (0.42 to 0.68)	0.82 (0.48 to 0.98)	0.94 (0.81 to 0.99)	0.25 (0.12 to 0.42)
Tooth mobility	0.22 (0.06 to 0.48)	0.86 (0.74 to 0.94)	0.33 (0.10 to 0.65)	0.78 (0.66 to 0.87)	0.17 (0.09 to 0.29)	0.91 (0.59 to 1.0)	0.92 (0.62 to 1.0)	0.16 (0.08 to 0.27)
Bone loss	0.56 (0.30 to 0.80)	0.72 (0.58 to 0.83)	0.36 (0.18 to 0.57)	0.85 (0.72 to 0.94)	0.4 (0.28 to 0.54)	1 (0.72 to 1.0)	1 (0.86 to 1.0)	0.23 (0.12 to 0.37)
Appearance	0.12 (0.02 to 0.38)	0.93 (0.83 to 0.98)	0.33 (0.04 to 0.78)	0.79 (0.67 to 0.88)	0.1 (0.04 to 0.20)	1 (0.72 to 1.0)	1 (0.54 to 1.0)	0.17 (0.09 to 0.28)
Flossing	1 (0.81 to 1.0)	0.95 (0.85 to 0.99)	1 (0.29 to 1.0)	0.75 (0.63 to 0.84)	0.05 (0.01 to 0.1 3)	1 (0.72 to 1.0)	1 (0.29 to 1.0)	0.15 (0.08 to 0.26)
Mouthwash	0.33 (0.1 3 to 0.59)	0.54 (0.41 to 0.68)	0.19 (0.07 to 0.36)	0.72 (0.56 to 0.85)	0.41 (0.29 to 0.54)	0.45 (0.17 to 0.77)	0.81 (0.64 to 0.93)	0.12 (0.04 to 0.25)
Diagnosis	0.71 (0.44 to 0.90)	0.65 (0.51 to 0.78)	0.39 (0.22 to 0.58)	0.88 (0.74 to 0.96)	0.46 (0.33 to 0.59)	0.73 (0.39 to 0.94)	0.9 (0.74 to 0.98)	0.2 (0.09 to 0.35)

PPV = positive predictive value; NPV = negative predictive value.

Table 6

Logistic Regression Models for Severe Periodontitis Cases

	Models*														
	1	**2†**	**2A**	**3**	**3A**	**4‡**	**4A**	**5§**	**5A**	**6//**	**6A**	**7¶**	**7A**	**8#**	**8A**
Participant characteristics															
Average age	X		X		X		X		X		X		X		X
Number of teeth	X		X		X		X		X		X		X		X
Dental insurance	X		X		X		X		X		X		X		X
Current needs	X		X		X		X	X	X		X	X	X		X
Current smoker	X		X		X		X		X		X		X		X
Diabetic diagnosis	X		X		X		X		X		X		X		X
Scale variables															
CDC-AAP 1. Gum disease		X	X	X	X	X	X					X	X		
CDC-AAP 2. Self-rating		X	X	X	X	X	X					X	X	X	X
CDC-AAP 3. Treatment		X	X	X	X	X	X	X	X	X	X			X	X
CDC-AAP 4. Tooth mobility		X	X	X	X					X	X			X	X
CDC-AAP 5. Bone loss		X	X	X	X	X	X	X	X	X	X				
CDC-AAP 6. Appearance		X	X	X	X							X	X		
CDC-AAP 7. Flossing		X	X			X	X								
CDC-AAP 8. Mouthwash		X	X												
Diagnosis								X	X	X	X			X	X
Odds ratio for scale		1.98	1.63	2.07	1.73	2.3	2.3	2.4	2.33	1.99	2.02	1.79	1.67	2.93	3.26
ROC/C-statistic	0.75	0.75	0.79	0.74	0.79	0.74	0.82	0.77	0.8	0.73	0.77	0.67	0.73	0.77	0.85

*The letter A indicates the model was statistically adjusted for the selected variables.

†CDC-AAP eight items only.

‡Best reduced model as reported on in Eke et al.[6]

§Scale item selected based on maximal sensitivity and specificity.

//Scale items selected to reflect periodontal history.

¶Scale items selected to reflect current periodontal burden.

#Scale items selected based on variable selection methods in a logistic model.