A Two-Domain Self-Report Measure of Periodontal Disease Has Good Accuracy for Periodontitis Screening in Dental School Outpatients

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Background: The assessment of periodontitis and treatment needs is primarily based on clinical and radiographic examinations. Albeit effective in predicting treatment needs, these examinations are costly, time-consuming, and impractical for assessing population-level needs. The purpose of the present study is to evaluate a two-domain self-report questionnaire for rapid periodontitis screening.

Methods: Six hundred white adult individuals, dentate or partially dentate and seeking dental therapy at a university clinic, underwent oral examination utilizing the full-mouth Community Periodontal Index of Treatment Needs (CPITN). To assess predictive value of self-reported periodontal measures (SRPMs) for periodontitis screening, four questions were formulated. Two questions aimed to assess "dentist-diagnosed periodontal disease" and two inquired about "self-assessed periodontitis." Multiple logistic regression models were used to construct receiver-operating characteristic curves, and predictor selection was performed via a forward stepwise selection process.

Results: Five hundred thirty-five volunteers with a mean age of 50.1 years elected to respond to SRPMs via telephone interview. After oral examination, 17.8% of participants were assessed as having CPITN = 4, representing compromised periodontal status. Sensitivity and specificity for correctly classifying compromised periodontal status ranged from 5.3% to 72.6%, and 87.8% to 99.5% for individual SRPMs. Sensitivity and specificity were increased when combining a measure of self-assessed periodontal disease and a measure of dentist-diagnosed disease as predictors. Addition of age and sex maximized sensitivity/specificity at 82.1%/82.2%. Diabetic status, smoking, and body mass index did not enhance the prediction.

Conclusions: A two-domain self-report measure combining two self-report items with age and sex has good sensitivity and specificity for periodontitis screening in a white, university-based population. The proposed self-report measure can be valuable for periodontitis screening in resource-limited settings where gold standard clinical examination may not be pragmatic. Further validation studies are required to assess whether findings from this study are context-specific. *J Periodontol 2016;87:1165-1173.*

KEY WORDS

Diabetes mellitus; diagnosis; periodontitis; sensitivity and specificity; smoking.

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Periodontal disease is an inflammatory disease that can compromise oral health–related quality of life and eventually lead to tooth loss.[1,2] Sixty-four million adults in the United States are estimated to suffer from periodontal disease, representing 46% of the US population, with 9% of the total population suffering from severe periodontitis.[3] Prevalence estimates in European countries vary largely due to heterogeneity among European populations and variations in screening methodologies in available epidemiologic studies.[4] Severe periodontitis prevalence estimates range from 9% of the adult population as reported in the 2009/2010 Adult Dental Survey in the U.K. to 17.4% of the adult population as reported in the fourth German Dental Health Survey.[5,6]

Assessment of periodontitis on a population level is primarily based on clinical and radiographic examinations.[1,7] These diagnostic procedures are satisfactory for individual screening, but they may be impractical and costly for population-based research in resource-limited settings. These drawbacks may impede conducting adequately powered population-based studies when it may be impractical to clinically assess the target population.[8] In studies aiming to investigate the effect of periodontitis with systemic diseases, such as diabetes mellitus (DM) and cardiovascular diseases among others, assessment of periodontal disease is often found to be the greatest challenge in terms of time, resources, and interexaminer variability.[9] Simple diagnostic tests, such as glycosylated hemoglobin levels for diagnosis of DM or self-report in the case of cardiovascular diseases are frequently used to assess prevalent chronic diseases; however, the gold standard for diagnosis of periodontal disease requires use of a mechanical probe subgingivally across the entire dentition.[10,11]

Currently, examiner-based protocols ranging from full-mouth examination with recording of continuous measures (i.e., probing depth and attachment levels) on six sites per tooth to categoric indices for periodontal disease screening (e.g., Community Periodontal Index of Treatment Needs [CPITN]) are used for population-level screening for periodontitis.[12] In an attempt to introduce examiner-independent periodontitis screening methods, researchers have proposed self-reported periodontal measures (SRPMs) to predict periodontitis when exam-based assessment is unattainable or impractical.[8,13-25] Compared with other indices for periodontal screening, predictive SRPMs can be a more time- and resource-effective alternative.[25] Although certain SRPMs have been shown to hold promise, their implementation has been hindered due to their low sensitivity, which is usually traded-off with high specificity.[26-28] A systematic review that included 16 original studies recorded a total of 20 self-report items previously used to predict periodontitis.[29] This systematic review concluded that selected self-report measures held promise in predicting periodontal disease in combination with demographic characteristics and risk factors. However, due to heterogeneity in combinations of self-report items in each study, various clinical measurements used, limited description of study populations, and lack of consistency in statistical analysis, additional research is needed to identify predictive combinations of self-report items for periodontitis screening.

In the present study a brief self-report questionnaire with a distinct two-domain structure: 1) screening questions for "dentist-diagnosed" periodontitis; and 2) screening questions for "self-assessed periodontitis" is evaluated. The authors hypothesize a combination of these two domains could increase sensitivity of a predictive model and enhance accuracy of prediction against a clinical index for periodontitis screening. CPITN is a commonly used periodontal evaluation index that, in different variations, has been adopted by the World Health Organization (Community Periodontal Index), the American Dental Association (Periodontal Screening and Recording index), and clinical researchers worldwide for periodontitis screening.[30-32] Thus, the aim of the present study is to evaluate whether a combination of self-report items in a predictive model structured to enhance sensitivity for predicting periodontal disease can have good accuracy compared with the CPITN.

MATERIALS AND METHODS

Sample Population

A previously reported university-based untreated sample population who visited the Aristotle University of Thessaloniki Dental School, Thessaloniki, Greece, seeking dental therapy was used. Characteristics and periodontal status of this population have been reported by Chatzopoulos et al.[33] Briefly, the sample population consisted of 600 adult, white, dentate or partially dentate individuals (279 males and 321 females, aged 18 to 87 years; mean age: ± SD: 50.5 ± 14.8 years) recruited from January 11 to April 11, 2014, in the outpatient clinic of the School of Dentistry at Aristotle University of Thessaloniki, Thessaloniki, Greece. Consenting participants underwent routine clinical oral examination and periodontal assessment utilizing the CPITN. 1) Demographic characteristics (sex, age), 2) history of DM (yes/no), and 3) current smoking status (yes/no) were collected from participant responses during interviews; and 4) height (meters), and 5) weight (kilograms) were measured during physical examinations to compute body mass index (BMI). Because these variables have been previously reported to be

associated with periodontal status in epidemiologic studies, they were adjusted for in the analysis. None of the participants needed antibiotic prophylaxis for clinical examination. The study protocol was approved by the ethical review board of the Aristotle University of Thessaloniki Dental School, Thessaloniki, Greece, in accordance with the Helsinki Declaration of 1975, as revised in 2013.

Periodontal Screening

For assessment of "screening for periodontitis" diagnosis, a full-mouth CPITN protocol was used and scoring was performed by a single, calibrated examiner (GSC) using a World Health Organization CPITN probe. Periodontal measurements were recorded at six sites around each tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual locations), except third molars. Participants with a maximum CPITN score of 4 at any site were considered to have active periodontitis.

The five CPITN scores used to evaluate periodontal status were:[34] 1) CPITN 0: no disease; 2) CPITN 1: bleeding on probing, no pockets; 3) CPITN 2: supra- or subgingival calculus, no pockets; 4) CPITN 3: deep periodontal pockets 3.5 to 5.5 mm; and 5) CPITN 4: deep periodontal pockets ≥6 mm.

Self-Report of Periodontitis

All participants were contacted for a telephone interview prior to disclosure of CPITN results. Two attempts were made to contact each participant before excluding them from the study. After requesting consent, a total of four questions were posed to each participant in the same order every time. All four questions had a binary response format (yes or no) and were: 1) Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?; 2) Have you ever had periodontal surgery?; 3) Do you think your teeth are loose or wobbly?; 4) Do you think you can see more roots of your teeth than in the past? These four questions were selected for their relatively acceptable accuracy as individual self-report measures based on previous investigations and for their representation of two distinct domains: 1) "dentist-diagnosed" periodontitis; and 2) "self-perceived" disease.[17,29,35,36] These questions were independently translated into Greek by two bilingual coinvestigators and any difference in translations was discussed until consensus was achieved. Oral self-report via telephone interviews was selected in this study to minimize disadvantages and risks of self-completion questionnaires. The interviewer can explain questions that the participant has not understood and minimize drop-out rate. On the other hand, written questionnaires and online surveys require reliable internet access, a motivated sample to return a complete survey as well as the ability to read, see, and write. A pilot study was also conducted prior to initiation of the study in a sample of 50 individuals not participating in the current study to evaluate comprehension (vocabulary appropriate to the target population) of questions. All four questions were easily understood by participants; thus, the form of questions was retained in the main study.

Statistical Analyses

For sample-size calculation, an expected sensitivity of 90% was considered, with a minimum acceptable lower confidence limit of 75% sensitivity ($\alpha = 0.05$). The minimum effective sample size, n = 70 cases, was determined according to the recommendations of Flahault et al.[37] For analyses and consistency with previous reports, participants with CPITN = 4 were considered to have active periodontitis, and the term "periodontitis" is used hereafter in this report.[34,38] The four self-report items were analyzed as dichotomous independent variables, and CPITN was dichotomized considering participants with CPITN = 4 as having "periodontitis" and those with CPITN ≤3 as having "no periodontitis." Simple logistic regression models were constructed with the dichotomized CPITN as the dependent variable and each of the self-report items as predictor variables to assess independent predictive weight of each self-report item. To test the hypothesis that combination of the two domains of self-reported periodontitis ("dentist-diagnosed" and "self-perceived") could increase sensitivity of a predictive model and enhance accuracy of prediction compared with individual self-report items, a forward stepwise selection method using minimization of the Sawa Bayesian Information Criteria as a selection criterion was used. To be consistent with previous reports, an additional set of potential covariates was included: 1) age, 2) current smoking status, 3) history of DM, and 4) BMI, as covariables in adjusted models.[8] Receiver-operating characteristic (ROC) curves were constructed based on parameter estimates from models, and area under the curve (computed via the c-statistic) was used for model comparison. ROC curve–derived confusion matrices were used to calculate sensitivity (true positives/total positives), specificity (true negatives/total negatives) and the c-statistic as a measure of accuracy for the selected models. To avoid model prediction bias, a resampling method with replacement (bootstrapping) was used. For models selected with the stepwise selection process c-statistics were derived via 1,000 bootstrap samples and reported bootstrap overfitting-corrected estimates of model performance (c-statistic). All analyses were completed using a statistical analysis package.§

§ JMP Pro 11.2.1, SAS Institute, Cary, NC.

RESULTS

Of the 600 adult participants enrolled in the clinical study, 535 volunteers (53.9% females) with an age range between 18 and 87 years (mean age ± SD: 50.1 ± 15.1 years) responded in the telephone interview (89.2% response rate). Main reasons for nonresponding were no answer (5.6%) and missing contact information (5.2%) (Fig. 1). This sample population included 41.3% smokers, 7.5% type 2 DM patients, and 31.1% obese (BMI mean ± SD: 27.8 ± 5.5 kg/m^2) that were fully or partially dentate with at least one tooth per sextant. After oral examination, 17.8% of participants were assessed as having periodontitis classified by CPITN = 4 (Table 1).

Eighty-seven participants responded positively to being told that they had periodontal disease or gum disease with bone loss (Q1: 16.3%), whereas only seven responded positively to having undergone gum surgery (Q2: 1.3%). Regarding items for "self-assessed" disease, 123 persons responded that they experienced tooth mobility (Q3: 23.0%) and 137 reported self-perceived recession (Q4: 25.6%) (Table 2). Specificity for individual self-report items ranged from 78.2% to 99.5%; thus, most participants who were categorized as not having periodontitis answered "No" to the screening questions. Sensitivity was low to moderate, ranging from 5.3% to 72.6%, and self-report items of "dentist-diagnosed" periodontitis misclassified the majority of participants having periodontitis (Table 3).

Automated variable selection among the set of four self-reported items selected a model combining one item from each of the two domains (Q1 and Q3) raising sensitivity/specificity of the predictive model

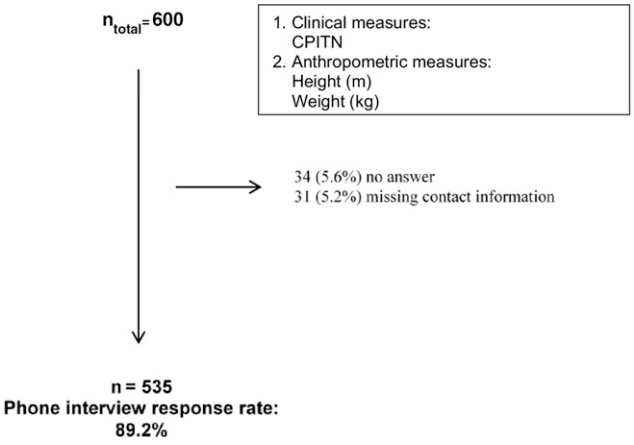

Figure 1.
Flowchart according to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.[39]

Table 1.

Basic Characteristics of Sample Population

Characteristics	CPITN <4 (n = 440) n (%)	CPITN = 4 (n = 95) n (%)	*P* Value*
Sex			<0.001
Males	184 (41.8)	60 (63.2)	
Females	256 (58.2)	35 (36.8)	
Age (years)			<0.001
≤39	126 (28.6)	5 (5.3)	
40 to 59	196 (44.6)	60 (63.1)	
≥60	118 (26.8)	30 (31.6)	
Smoking			0.051
Yes	270 (61.4)	48 (50.5)	
No	170 (38.6)	47 (49.5)	
Diabetes mellitus			0.094
Yes	29 (6.6)	11 (11.6)	
No	411 (93.4)	84 (88.4)	
BMI (kg/m^2)			0.1
<18.5 (underweight)	10 (2.3)	0 (0)	
18.5 to 24.9 (normal)	144 (32.7)	22 (23.2)	
25 to 29.9 (overweight)	150 (34.1)	40 (42.1)	
≥30 (obese)	136 (30.9)	33 (34.7)	

* *P* values for comparisons between CPITN <4 and CPITN = 4 subgroups arise from χ^2 tests for categoric variables.

Table 2.

Description of Self-Report Items

Self-Report Periodontal Health Questions	Positive Responses n (%)
Professional diagnosis of periodontal disease	
Q1. "Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?"	87 (16.3)
Q2. "Have you ever had periodontal surgery?"	7 (1.3)
Self-perceived periodontal disease	
Q3. "Think teeth loose or wobbly?"	123 (23)
Q4. "Think you can see more of roots of teeth than in past?"	137 (25.6)

Table 3.

Validity Parameters for Predictive Models for Self-Report of Periodontitis

Univariate Models			Two-Domain Models		
Dentist-diagnosed periodontitis					
Q1. "Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?"	Sensitivity	0.46	Model 1*	Sensitivity	0.80
	Specificity	0.90	Q1. "Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?"	Specificity	0.83
	C-statistic	0.68	AND	C-statistic	0.83
	PPV	0.50 (0.82)†	Q3. "Think teeth loose or wobbly?"	PPV	0.51 (0.82)†
	NPV	0.88 (0.63)†		NPV	0.95 (0.81)†
Q2. "Have you ever had periodontal surgery?"	Sensitivity	0.05			
	Specificity	1.00			
	C-statistic	0.52			
	PPV	1.00 (1.00)			
	NPV	0.83 (0.51)†			
Self-perceived disease	Sensitivity	0.73	Model 2‡	Sensitivity	0.82
Q3. "Think teeth loose or wobbly?"	Specificity	0.88	Q1. "Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?"	Specificity	0.82
	C-statistic	0.80	AND	C-statistic	0.87
	PPV	0.57 (0.86)†	Q3. "Think teeth loose or wobbly?"	PPV	0.50 (0.82)†
	NPV	0.94 (0.77)†	AND age and sex	NPV	0.95 (0.82)†
Q4. "Think you can see more of roots of teeth than in past?"	Sensitivity	0.43			
	Specificity	0.78			
	C-statistic	0.61			
	PPV	0.30 (0.66)†			
	NPV	0.86 (0.58)†			

PPV = positive predictive values; NPV = negative predictive values.
Dichotomous CPITN was considered the gold standard for periodontitis screening.
* Combination of Q1 and Q3 based on forward stepwise selection.
† Predictive values in parentheses are standardized values computed based on a projected prevalence = 50% estimate.[40]
‡ Model 1 + age + sex (female was the reference category for sex, whereas age was treated as a continuous variable).

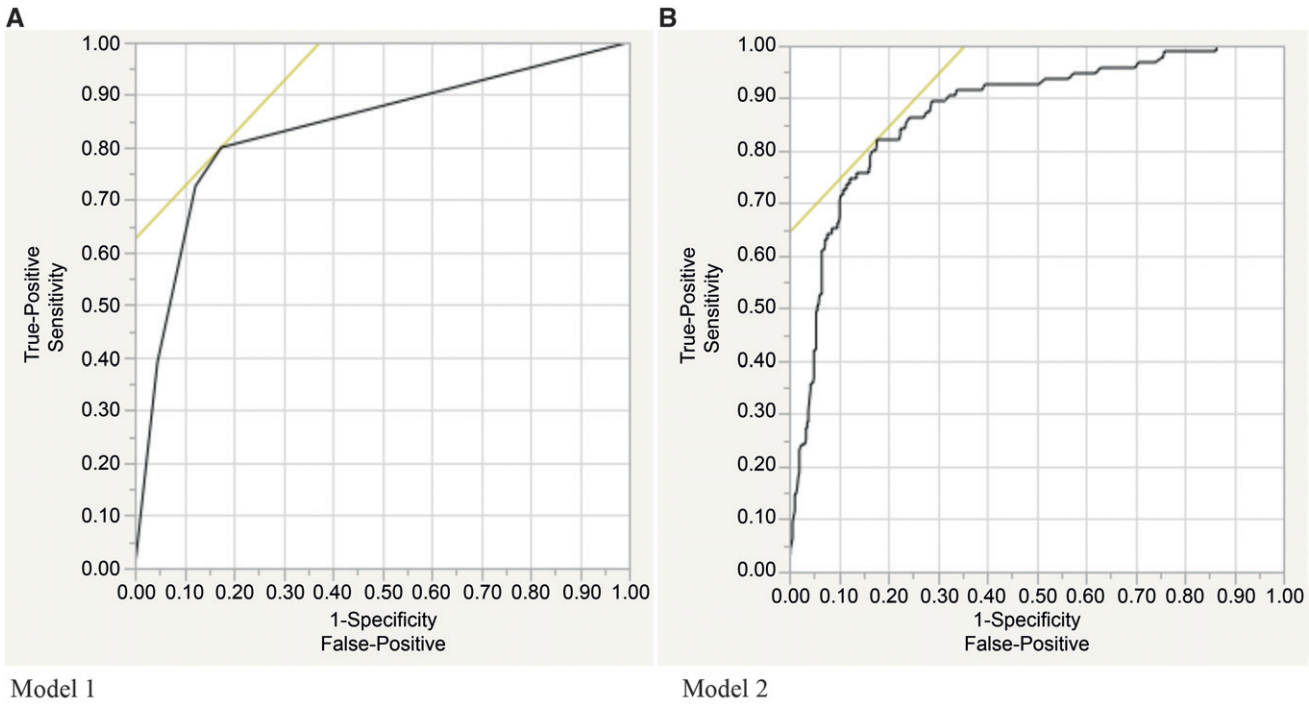

Figure 2.
A) *ROC curve of prediction model 1 (Q1. "Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?" AND Q3. "Think teeth loose or wobbly?").* ***B)*** *ROC curve of prediction model 2 (Q1. "Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?" AND Q3. "Think teeth loose or wobbly?" AND age AND sex).*

to 80.0%/82.5% (c-statistic = 0.83) (Table 3; Fig. 2). Addition of age and sex maximized the c-statistic at 87.4 (sensitivity/specificity 82.1%/82.2%, Table 3; Fig. 2), whereas addition of diabetic status, smoking, and BMI did not enhance the prediction (all *P* values >0.05, data not shown).

DISCUSSION

In this study, 535 outpatients attending a university-based clinic for initial dental examination responded to a self-report periodontal interview for periodontitis screening. The study hypothesis was that a combination of self-report measures from two distinct domains (''dentist-diagnosed'' and ''self-assessed'') would minimize false-negative responses by capturing more periodontitis cases, thus increasing sensitivity of a predictive model. The hypothesis was validated, as the best predictors for periodontitis screening seemed to be the combination of a self-report measure of dentist-diagnosed disease (''Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?'') with a measure of self-assessed periodontal disease (''Think teeth loose or wobbly?''). Age and sex, but not smoking and DM, also played a pivotal role in the model's predictive ability.

In crude analyses, all four questions yielded acceptable specificity of at least 78%, with low sensitivity ranging from 5.2% to 72.6%. Generally sensitivity and specificity levels exceeding 75% are considered acceptable for diagnostic tests, whereas sensitivity and specificity exceeding 80% are considered good.[41] Predictive ability of the model was dramatically increased by combining one question from each of the two domains. Increased sensitivity of the two-domain model in this study means many participants with compromised periodontal status were either aware of their periodontal condition or had been previously informed by a dentist.

Previous efforts to instill self-report measures for periodontics screening have investigated either single self-report items[17,36] or predictive models based on multiple self-reported items.[8] The first approach favors simplicity and is more practical, whereas the latter is based on the hypothesis that multiple self-reported items can enhance accuracy of prediction. Generally, single self-report items tend to yield low sensitivity with acceptable sensitivity for periodontitis screening.[8,9,14-16,35,36] Gilbert and Nuttall[36] interrogated a population of 100 university patients with the question, "Were you told by your dentist/hygienist that you have gum disease?" in a mailed questionnaire. They found, depending on the gold standard

periodontitis definition, sensitivity for this single item ranged from 29% to 32%, with a 94% specificity. Similarly, sensitivity for self-reported tooth mobility (''Think teeth loose or wobbly?'') ranged from 29% to 32%, whereas specificity was between 92% and 94% compared with clinical mobility of teeth.[36] In another study, 145 VA Dental Longitudinal Study participants were asked the same question with the addition of a criterion for bone loss: ''Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?''[35] This dentist-diagnosed disease self-report item yielded a 33% to 50% sensitivity range, with a specificity range of 78% to 82% depending on the selected gold standard definition for periodontitis. Similar studies assessing single self-report items from the ''self-assessed periodontitis'' domain show the same pattern of low sensitivity.

To enhance accuracy of self-report screening models, Dietrich et al.[8] delivered a 21-item self-report questionnaire to 246 individuals attending endodontic treatment and built various prediction models. Their results suggested that considering the need for restriction in the number of self-reported items in questionnaires, incremental value of assessing more than two or three of them is limited. Moreover, in agreement with results from the current study, they found age and sex have substantial predictive value when added as explanatory variables in the disease prediction model. The present study in particular contributes to the conceptual foundation of multiple-item prediction models by highlighting the merit of combining items from each of the two aforementioned domains in the final outcome measure. Indeed, the final predictive model combining periodontitis risk indicators and self-report items representing a two-domain structure maintained a balance between both good sensitivity (82.1%) and specificity (82.2%). In contrast, all single self-report item models yielded sensitivities <75%.

There are certain limitations to this study. Cross-sectional design of the current dataset precludes any inference to the validity of the proposed two-domain self-report measure to assess periodontal status longitudinally. Residual confounding may exist as factors such as: 1) socioeconomic status; 2) educational level; 3) cognitive dissonance; and 4) access to dental care could not be adjusted for due to lack of data. Thus, their confounding and individual effects remain unknown. Nonetheless, according to the Eurobarometer for Oral Health in 2010, only 49% of Greeks visited a dental office in the previous year.[42] This fact may, at least partially, explain the very low positive response rate to the self-report item inquiring about history of periodontal surgery (Q2: 1.3%) in this sample population. In addition, this university-based sample population may be more representative of people with lower socioeconomic status and may not be representative of private practice–treated populations. Future studies with more diverse sample populations are required to assess whether the findings of this study are context-specific. Patients also knew the interviewer might know their clinical data and this might have affected the answering of behavior-based interview questions. Validation studies are required to assess predictive validity of the proposed two-domain self-report measure via both oral and written self-reports. In this study, current smoking status was recorded during interviews, and potential negative effect of former smoking on periodontal tissues was not examined. Social desirability bias in self-report current tobacco use might have led to underestimation of its predictive ability, since it was not found to significantly enhance predictive ability of the models.[43] In future studies, model questions regarding former smoking status should also be included in periodontitis prediction models to increase sensitivity of self-report measures. It is necessary to perform validation studies in diverse new sample populations to assess whether findings from the current study are context-specific.

CONCLUSIONS

This study confirmed the hypothesis that a two-domain self-report measure of periodontal disease combining two self-report items with age and sex has good sensitivity and specificity for periodontitis screening in a white population attending a university clinic for dental care. The combination of two SRPMs, one evaluating ''dentist-diagnosed periodontal disease'' and one ''self-diagnosed periodontitis,'' can be a valuable measure for periodontitis screening in resource-limited settings where gold standard clinical examination may not be pragmatic. The proposed self-report measure can also be used for preliminary screening of large populations prior to clinical examination of potential participants. Further studies are required to assess whether these findings are context-specific.

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