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Oral Health Literacy and Measures of Periodontal Disease

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Abstract

Background—Existing evidence demonstrating a relationship between health literacy (HL) and periodontal health is insufficient to identify how providers can help patients manage periodontal disease. This study assesses associations between HL measures (word recognition, numeracy, and conceptual knowledge) and signs of periodontal disease.

Methods—This study included 325 new patients at a dental school clinic and employed an oral HL (OHL) survey, full-mouth radiographs, and clinical examination. Evaluations included the relationship between each HL measure versus number of teeth, bleeding score, plaque score, and periodontal severity with linear and ordinal logistic regression models before and after adjusting for covariates.

Results—Among HL measures, the Newest Vital Sign demonstrated a significant relationship with number of teeth and the Short Test of Functional Health Literacy in Adults showed a significant association with plaque score. The short Rapid Estimate of Adult Literacy in Medicine and Dentistry (REALMD-20) showed participants who performed in the highest quartile had nearly two additional teeth, over 5.5% fewer bleeding sites, and nearly 9% fewer teeth with plaque after adjustment for demographic variables, smoking, and diabetes mellitus (DM). Participants who scored in the highest quartile of the Comprehensive Measure of Oral Health Knowledge (CMOHK) had nearly 9% less plaque.

Conclusions—Two OHL instruments (REALMD-20 and CMOHK) provided statistical associations with clinical measures of periodontal health at a level that could be considered of moderate clinical relevancy. Findings suggest dentists may wish to assess familiarity of their patients with dental terminology and knowledge of periodontal disease to provide education on oral hygiene, smoking, and DM.

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Keywords

Diabetes mellitus; health; health education; oral health; smoking

Health literacy (HL) encompasses "... knowledge, motivation and competences to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life during the life course".¹ Current HL instruments use a variety of strategies to measure these capabilities. Instruments like: 1) the Rapid Estimate of Adult Literacy in Medicine (REALM) measure word recognition;² 2) the short Test of Functional Health Literacy in Adults (short TOFHLA) tests reading comprehension;³ 3) the supplementary HL screening measure developed by Chew et al.⁴ asks individuals to report "... problems learning about your medical condition because of difficulty with understanding written information"; and 4) the Newest Vital Sign (NVS) tests numeracy and locate-the-information skills.⁵

The relationship between HL and health is well documented in a systematic review.⁶ Low HL is associated with higher use of urgent health care (e.g., hospitalizations, emergency care) and less use of health promotion and preventive services, poor medication adherence, and increased morbidity and mortality in the elderly.⁶

Oral HL (OHL) focuses specifically on the complexity of factors that affect the ability of an individual to make judgments and decisions concerning their oral health.⁷ Lower OHL has been associated with: 1) less dental knowledge;^{8–13} 2) self-report of poor oral health;^{11,14–17} 3) irregular followup dental visits;¹⁴ 4) less seeking of health information;^{14,18} and 5) less access to dental care.^{10,12,18} Some measures of periodontal disease (e.g., periodontal severity/attachment loss; decayed, missing, and filled teeth; missing teeth; and *Lactobacillus* levels) have also been shown to be associated with OHL.^{13,19,20} Similar to general HL, OHL indicates: 1) knowledge of the conceptual processes responsible for dental disease; 2) ability to apply that understanding; 3) ability to incorporate self-care behaviors; and 4) ability to navigate the health care system when needed.⁷

Understanding associations among multiple factors, such as smoking behavior, OHL, diabetes mellitus (DM), and periodontal disease is not well understood. A systematic review of epidemiologic observational evidence assessing the association between DM and periodontal disease while controlling for smoking demonstrated periodontal disease is a significant risk factor for DM, after controlling for smoking.²¹ No studies included in the review had HL or OHL as mediating factors. One study examining OHL and periodontal status showed, in bivariate analysis, that higher OHL was significantly related to better periodontal health even after controlling for smoking, dental insurance, and race. Although DM and education were recorded for patients, they were not included in the multivariate analysis.¹⁹ In a separate study²² of adults with type 1 or type 2 DM, the authors found that although HL had no significant direct association with glycemic control, HL did have a direct association with DM self-efficacy. Through DM self-efficacy, HL had a significant indirect association with glycemic control.²² Thus, a better understanding of the relationship between OHL, periodontal disease, and its risk factors is important to help

clinicians tailor effective approaches to educate patients on how to prevent and manage chronic periodontal disease.

This study assesses associations of HL and OHL measures with the clinical periodontal measures number of teeth, bleeding score, plaque score, and periodontal severity after accounting for sociodemographic factors, smoking, and DM.

MATERIALS AND METHODS

The sample includes all participants from California enrolled in the National Institutes of Health-supported Multicenter Assessment of Health Literacy and Oral Health, approved by the Institutional Review Board at University of California, Los Angeles (UCLA), Los Angeles, California, consisting of 466 new adult patients (240 males and 226 females, aged 18 to 87 years; mean age: 46.6 years) of the UCLA School of Dentistry recruited at the general and Venice clinics of the dental school from June 2012 to September 2013. Potential participants were eligible if they: 1) were aged 18 years or older; 2) had no cognitive, vision, or hearing difficulties that interfered with their ability to complete the survey; 3) were not working or training in the health care field; 3) had fewer than five visits to the dental school; or 4) if they were former patients of the school, had no dental visit at the school for more than 5 years. Participants were queried as to the number of visits they had before they took the survey. Recruitment/notification of the study opportunity was presented in multiple ways to encourage larger patient participation: 1) printed cards describing the study were placed in the waiting room; 2) a television monitor displayed information about the study; and 3) new patients to the school were invited to participate while waiting for their dental radiographs to be taken. Individuals interested in participating contacted study staff. Participants provided written consent, and the 40-minute survey was administered in a private office. After completion of the survey, study participants were given educational oral health materials and \$35 cash.

Participants were included in this cross-sectional analysis if, in addition to completing the oral health survey they had: 1) full-mouth radiographs; 2) a clinical examination of both teeth and periodontal tissues; and 3) at least one tooth with periodontal measures (probing depth [PD] and attachment loss [AL]) as a part of their initial evaluation and prior to dental treatment. The full-mouth radiographic examination was made by the oral radiology technician, and the clinical examination and charting was completed by the regularly assigned dental student of each participant, using one of two periodontal probes in use in the student clinic, either the Marquis probe (3-mm increments) or the University of Michigan probe (1-mm increments). In both cases, students rounded to the nearest mm. Edentulous participants were excluded from this analysis. Of 456 potential candidates, 325 met the above inclusion criteria.

Figure 1 describes the framework that guides analysis of the association of HL and clinical periodontal measures, after accounting for sociodemographic factors, smoking, and DM. In the oral health survey, participants were asked to self-identify: 1) their race and ethnicity; 2) whether they currently had dental insurance (Y/N); and 3) their estimated annual household income. Race/ethnicity was analyzed using five categories: 1) non-Hispanic white; 2)

Hispanic; 3) non-Hispanic black; 4) non-Hispanic Asian; and 5) other/mixed race. Household income was divided into six categories: 1) \$0 to \$11,000; 2) \$11,001 to \$22,000; 3) \$22,001 to \$33,000; 4) \$33,001 to \$44,000; 5) \$44,001 to \$55,000; and 6) >\$55,000. Participants identified their highest grade or year of completed school categorized as: 1) <12th grade; 2) grade 12/general educational development certificate (GED); 3) some college; or 4) college graduate. Participants with graduate degrees (e.g., Juris Doctor, master) were considered college graduates. For this analysis, acculturation was estimated from a single survey question asking participants what language(s) s/he spoke as a child. Those who spoke no English as a child were compared with all those who spoke English.²³ Age in years (18 to 24; 25 to 44; 45 to 64; and >65), sex (M/F), smoking status (current/former smoker or never smoked), and DM status (has DM; other family history of DM; no history of DM) were obtained from the dental school electronic dental record (EDR) of participants.

Three validated general HL and two OHL instruments were chosen for this analysis. The three well-recognized general HL instruments used were the short TOFHLA, the NVS, and a screening question developed by Chew et al.^{3–5} The short TOFHLA consists of 36 reading comprehension items in which participants select from among given words the correct words to complete instructions for preparation for an upper gastrointestinal radiographic series and sections of a Medicaid application, a test format called the modified Cloze procedure.³ The NVS, an HL screening tool based on a nutritional label, consists of six questions requiring mathematic and locate-the-information skills.⁵ The NVS has been scored as high likelihood of limited literacy (0 to 2 correct), possibility of limited literacy (3 to 4 correct), and adequate literacy (5 to 6 correct).⁵ The Chew screening question asks participants how often they experienced problems learning about their medical condition because of difficulty understanding written materials, with responses ranging from all of the time (a score of 5) to none of the time (a score of 1). A score 2 indicates inadequate HL, and a score of 1 is considered an indication of adequate HL.⁴

Two OHL measures were selected for the analysis: the shortened form of the Rapid Estimate of Adult Literacy in Medicine and Dentistry (REALMD-20) and the Comprehensive Measure of Oral Health Knowledge (CMOHK).^{14,24,25} The REALMD-20 consists of 20 words from the Rapid Estimate of Adult Literacy in Medicine and Dentistry (REALM-D), which is a valid and reliable word recognition screening instrument that incorporates 18 dental terms into the existing 66-item REALM.¹⁴ Despite the reduction in length, the REALMD-20 has been shown to have comparable validity/reliability as the REALM-D instrument.²⁴ Participants are asked to read each REALM-D word, and those pronounced correctly were scored 1 point, those mispronounced or not attempted received no points. The CMOHK is a valid and reliable measure consisting of 23 items describing conceptual oral health knowledge about oral anatomy, caries, periodontal disease, and oral cancer.²⁵ The Cronbach α reliability coefficients for this sample are $\alpha = 0.88$ for the REALMD-20 and $\alpha = 0.69$ for the CMOHK.

The clinical examination (including evaluation of soft and hard tissues as well as probing) was conducted as a part of the standard new patient exam by the treating dental student (name unknown) of the patient (3rd to 4th year). The exam was checked by the overseeing

periodontal faculty, and data was entered into the EDR of each patient. Clinical oral health measures (number of teeth present, periodontal pockets, AL, plaque score, a score summing the number of sites with bleeding) were abstracted by the first author from the existing EDR of each patient. Root tips were recorded as teeth present. Third molars, abutments, and implants were recorded as missing teeth. Number of teeth present was summed by the abstracting dentist. Using existing clinical measurements in the EDR, the dentist recorded the highest score for periodontal pockets and AL for each tooth (buccal, lingual, or interproximal) for any individual tooth. This modification introduced gingival recession into the determination of historic disease severity. Overall severity of periodontal disease was determined using a criterion similar to the Periodontal Severity Index (PSI) to enable comparison.²⁶ Mild periodontitis was defined as two or more teeth with a site of AL ≥ 3 mm and two or more teeth with PD ≥ 4 mm or one tooth with PD ≥ 5 mm. Participants with two or more sites with AL ≥ 4 mm (not on the same tooth) or with two or more sites with PD ≥ 5 mm (not on the same tooth) were considered to have moderate periodontal disease. Participants with two or more teeth with sites of AL ≥ 6 mm and one or more teeth with sites of PD ≥ 5 mm were considered to have severe periodontitis.²⁷

Statistical Analyses

A power assessment was based on the periodontal severity score using the sample size that was available using an ordinal outcome with categories of 0 = none/mild, 1 = moderate, and 2 = severe. An odds ratio (OR) was computed of having lower (better) periodontal severity score, comparing the test group with the control group, that could be confirmed with 80% power, $\alpha = 0.05$, under the ordinal logistic regression model. For a given health literacy predictor, the test group is defined as the highest quartile, and the control group is defined as the lowest quartile. Using the available sample, it was found that ORs as low as 2.1 to 2.5 could be confirmed, which is viewed as a clinically relevant size, with 80% power, $\alpha = 0.05$, under the ordinal logistic model. An assessment was made of the association between periodontal severity and clinical periodontal measures with demographic factors, smoking, and DM. The bivariate relationship between periodontal severity and clinical measures versus each demographic variable was evaluated using the Wilcoxon rank sum test (categorical variables) or the Spearman correlation (ordinal variables). Association between each HL and OHL measure was evaluated versus number of teeth and proportion of bleeding sites before and after, adjusting for up to nine demographic factors using the robust bootstrapping linear regression analysis. This method did not impose any distribution assumptions on the outcome variable, since number of teeth and proportion of bleeding sites did not have a normal distribution. Standard errors of the parameter estimates were computed empirically using 500 resamplings of the data under the above models. The relationship between each HL measure and plaque score was evaluated similarly using least squares linear regression, the mean changes corresponding to comparisons of the highest with the lowest quartile of the specified HL predictor (in case of continuous predictors).

The relationship between periodontal severity versus HL measures was investigated using the ordinal logistic regression model with and without adjustment for up to nine demographic factors after confirming the proportional odds assumption using the score test. To determine the final OR, non-significant predictors were removed to arrive at the final

adjusted model. Results are summarized using ORs of having a lower periodontal severity score, its 95% confidence intervals (CIs) and *P* values under the above logistic models. Final regression models were selected using the backward procedure for variable selection and liberal $P < 0.25$ as the retention criterion.

RESULTS

The sample was 54.2% male and had a mean age of 46.3 years with 15.1% of the population over the age of 64 years. Approximately half the sample was non-Hispanic white, one-quarter was Hispanic, 11.7% was non-Hispanic black, 7.1% was non-Hispanic Asian, and 8.6% was other or mixed race (Table 1). Approximately 20% of the sample did not speak English as a child, which was considered a marker of being less acculturated. Eighteen percent of the sample had no more than a grade 12 education or a GED; approximately two-thirds reported household incomes of \$55,000, and nearly three-quarters of the sample did not have dental insurance.

Regarding health matters, a little over 5% of the population reported having DM in their EDR-reported medical history, whereas 35.7% had a family history of DM, and 16% reported being current smokers. Using the constructed periodontal severity measure, 54% and 37% of the sample had moderate and severe periodontal disease, respectively. More severe periodontal disease was significantly associated with: 1) race/ethnicity; 2) older age; 3) lower educational attainment; 4) not having dental insurance; and 5) being a current or former smoker (Table 1). A trend was observed for more severe periodontal disease and being male ($P = 0.054$). DM and the measure of acculturation were not significantly associated with periodontal severity.

The sample had a mean of 25.10 teeth ($q1 = 24.00$; $q3 = 28.00$), a mean of 16.26% bleeding sites ($q1 = 0.91\%$; $q3 = 23.44\%$), and a mean plaque score of 39.33% ($q1 = 21.88\%$; $q3 = 53.91\%$). Examining the bivariate associations (less than a 0.05 level of significance) for sociodemographics and number of teeth, significant differences were found among number of teeth and race/ethnicity, age, education, income, having dental insurance, and smoking status (Table 2). Similar to periodontal severity, there was no significant association between number of teeth and DM and acculturation. There were no significant bivariate associations between bleeding score or plaque score and patient demographics, and there was no significant association between DM and any clinical measure. However, a trend was observed for plaque score and race/ethnicity ($P = 0.08$) and smoking status ($P = 0.08$).

Logistic regression results for evaluating periodontal severity and measures of general HL with and without adjusting for the sociodemographic, DM, and smoking factors are provided in Table 3. ORs reported summarize the association between each specified predictor (highest versus lowest quartile) versus the odds of having a lower periodontal severity score. In the unadjusted analysis, participants with NVS scores of >5 have 1.94 times greater odds of having a better periodontal severity score compared with those who had NVS scores of ≤ 5 ($P = 0.01$). However, the relationship between NVS score and periodontal severity was no longer significant after adjustment for age, sex, and race/ethnicity. Regarding the Chew et al.³⁻⁵ screening item, in the unadjusted analysis, participants who report “a little of the time

having difficulty understanding written materials” had 2.01 times greater odds of having a better periodontal severity score than those with no difficulty ($P < 0.01$), and after adjusting for age, sex, and race/ethnicity, a trend remains at $P = 0.056$. However, there were no differences in the periodontal severity score for participants with difficulty “some or all of the time” compared with those with no difficulty before or after adjusting for demographic factors (adjusted OR = 0.68; $P = 0.18$). Participants with short TOFHLA scores in the highest quartile had 1.93 times greater odds of having a better periodontal severity score compared with those who had short TOFHLA in the lowest quartile ($P = 0.03$). However, these associations are greatly diminished and are not significant after adjustment for age, sex, and race.

Regarding OHL measures, the sample had a mean REALMD-20 score of 17.4 and CMOHK score of 17.5. Higher REALMD-20 (OR 1.48; $P = 0.28$) and higher CMOHK (OR 1.45; $P = 0.25$) tended to be associated with better periodontal severity score in the adjusted analysis, although these associations did not reach statistical significance.

There were significant associations between some epidemiologic clinical measures and two HL measures (NVS, short TOFHLA) and OHL measures (REALMD-20 and CMOHK) (Table 4). Table 4 summarizes linear regression results for evaluating the relationship between each of the clinical measures versus each of the HL measures before and after adjusting for demographic, DM, and smoking factors. Mean changes correspond to comparisons of the highest with the lowest quartile of the predictor. There were significant associations between greater number of teeth with the NVS before and after adjustment for age, race, education, smoking, income, and DM. There were significant associations between lower plaque scores with higher short TOFHLA score and a trend with higher NVS score (score of 5 to 6) before and after adjustment for DM (Table 4). There were no significant associations between the Chew et al.³⁻⁵ screening question and any epidemiologic clinical measure.

There were significant associations between greater number of teeth with REALMD-20 scores, and a trend with CMOHK scores before and after adjustment for age, race, education, smoking, income, and DM. Patients who had REALMD-20 scores in the highest quartile had almost two more teeth on average than those in the lowest quartile, adjusting for sociodemographic factors ($P = 0.002$). Significant associations with a lower bleeding score exist with REALMD-20 and CMOHK scores. In unadjusted analysis, those who scored in the highest quartile of the REALMD-20 had 5.63% ($P = 0.03$) lower bleeding score and those in the highest CMOHK had 6.67% ($P = 0.02$) lower bleeding score on average than those in the lowest quartiles. The relationship between lower bleeding score and higher REALMD-20 score remained significant after adjustment for race, dental insurance, and DM (mean change 5.52%; $P = 0.046$). The relationship between lower bleeding score and a higher CMOHK score approached statistical significance after adjustment for the above factors. There were significant associations between lower plaque scores with higher REALMD-20 scores and higher CMOHK scores before and after adjustment for DM. Those in the highest quartiles of REALMD-20 and CMOHK had approximately 9% ($P < 0.02$) lower plaque scores on average after adjusting for DM (Table 4).

DISCUSSION

The sample under analysis was generally healthy and educated but poor and uninsured, which may represent a limitation in a study of HL. Participants had: 1) lower levels of DM (5.2%) than the national average (9.3%);²⁸ 2) slightly lower rates of smoking (current smokers 16% versus 17.8%);²⁹ and 3) higher educational attainment, with only 4.3% having <12th grade education compared with 9% nationally and 50.8% college graduates compared with 34% nationally.³⁰ Median household income in Los Angeles is \$55,909.³¹ In this sample, 47.4% of participants reported household incomes of <\$33,000.

The study used existing clinical data collected by the treating dental students during the standard initial exam of new adult patients. Although this may be considered a limitation and introduce a lack of precision compared with an epidemiologic exam, it also represents actual clinical practice-type data, which may make findings more clinically relevant. The data suggest a sample of patients with most of their teeth, but moderate to high levels of periodontal disease. Nine percent of participants had no/mild periodontal disease, with 54.2% having moderate and 36.6% severe periodontal disease. This is significantly more disease than would be expected since nationally only 38% of the US adult population 30 years and older has moderate/severe periodontal disease using the PSI.³² This may reflect greater AL scores due to inclusion in the current study of gingival recession in the periodontal severity score construction. However, the data corresponds with a small North Carolina sample of dental school participants receiving periodontal care who also reported similar percentages of DM(5%), current smoking (13%), and periodontal disease (53% with severe periodontal disease).¹⁹ High prevalence of periodontal disease may also represent unforeseen selection bias; individuals with high education but lower income may seek out ways to access high-quality, lower-cost dental care and therefore seek care at a dental school.

In general, few and inconsistent associations were found between general HL measures and clinical oral health outcomes using multivariate analyses that adjusted for sociodemographic characteristics, smoking, and DM. The NVS demonstrated a clinically significant relationship with number of teeth and a trend toward an association with plaque score, but no association with periodontal severity or bleeding. The Chew et al.⁴ screening question showed no significant associations with any clinical periodontal measure after proper adjustment for sociodemographics, DM, and smoking. The short TOFHLA showed a significant association with plaque score after adjustment for DM. The inconsistency of these findings may suggest NVS, short TOFHLA, and the single Chew et al.⁴ screening question are not useful measures to enable a clinician to assess HL of a patient when considering their knowledge of periodontal disease.

OHL measures showed a different picture. The REALMD-20 demonstrated consistent associations in the correct direction for the epidemiologic clinical oral health measures. Participants who performed in the highest quartile of the brief REALMD-20: 1) had nearly two additional teeth than those who scored in the lowest quartile; 2) had over 5.5% fewer bleeding sites; and 3) had nearly 9% fewer teeth with plaque on average after adjustment for appropriate demographic variables, and, in each case, DM. This is, to the best of the authors'

knowledge, the first study to show DM is an important mediator with respect to oral health of a patient, using any of the epidemiologic measures, and OHL. DM is a complex disease that is difficult for patients to manage. Thus, since DM also has a known association with periodontal disease, it would be useful for clinicians to have a brief tool that could alert them to specific patients with lower OHL. The CMOHK would also be informative to the clinician when evaluating OHL and the plaque score of patients. Participants who scored in the highest quartile of the CMOHK had nearly 9% less plaque. One domain of the CMOHK is oral health prevention and thus may tap into knowledge of participants of appropriate prevention of periodontal disease.

Insufficient research has been conducted to understand the role of DM and smoking with HL and oral health outcomes. In this study, DM was a significant mediator when assessing clinical oral health measures of number of teeth, sites of bleeding, and plaque score when using the REALMD-20, CMOHK, and short TOFHLA. Smoking status was significant only for number of teeth, leaving questions needing to be addressed regarding the association among HL and OHL and periodontal disease. Type of clinical measure used makes a difference in the result. The constructed periodontal severity score generally showed no associations with HL or OHL after appropriate adjustments for socioeconomic, DM, and smoking factors. The simple count of number of teeth reflects both history of dental disease and dental treatment. The plaque score is unique because it is the only measure to provide evidence of up-to-date patient behavior. The bleeding score reflects both behavior and dental disease, but was only associated using the REALMD-20. Future prospective research could narrow down the effect of behavioral interventions for patients with low OHL.

CONCLUSIONS

Two OHL instruments provided statistical associations with a broad range of clinical measures of periodontal health at a level that could be considered of moderate clinical relevancy. Findings suggest dentists may wish to assess familiarity of their patients with dental terminology and knowledge of periodontal disease to provide education on oral hygiene, smoking, and DM.

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Figure 1.
Conceptual framework measuring association between periodontal disease and HL.

Bivariate Relationships Between Demographics of Sample Population Versus Periodontal Severity

Table 1

	n (% of entire sample)	Periodontal Severity n (%)			P Value
		None/Mild (0)	Moderate (1)	Severe (2)	
Entire sample	325 (100)	30 (9)	176 (54)	119 (37)	
Sex					
Males	176 (54.2)	13 (7.4)	91 (51.7)	72 (40.9)	0.05
Females	149 (45.9)	17 (11.4)	85 (57.0)	47 (31.5)	
Race/ethnicity					
Non-Hispanic white	161 (49.5)	9 (5.6)	92 (57.1)	60 (37.3)	0.002
Hispanic	75 (23.1)	10 (13.3)	40 (53.3)	25 (33.3)	
Non-Hispanic black	38 (11.7)	2 (6.3)	16 (42.1)	20 (52.6)	
Non-Hispanic Asian	23 (7.1)	6 (26.1)	15 (65.2)	2 (8.7)	
Other/mixed race	28 (8.6)	3 (10.7)	13 (46.4)	12 (42.9)	
Age (years)					
18 to 24	31 (9.5)	7 (22.6)	21 (67.7)	3 (9.8)	<0.001
25 to 44	112 (34.5)	14 (12.5)	74 (66.1)	23 (20.5)	
45 to 64	133 (40.9)	8 (6.0)	59 (44.4)	66 (49.6)	
>64	49 (15.1)	1 (2.0)	21 (42.9)	27 (55.1)	
Education					
College graduate	165 (50.8)	15 (9.1)	94 (57.0)	56 (33.9)	0.02 (comparing education <12 grades with education ≥12 grades)
Some college	98 (30.2)	11 (11.2)	50 (51.0)	37 (37.8)	
Grade 12/GED	45 (13.9)	3 (6.7)	25 (55.6)	17 (37.8)	
<Grade 12	14 (4.3)	0 (0.0)	5 (35.7)	9 (64.3)	
Spoke English as a child					
Yes	258 (79.4)	21 (8.1)	138 (53.5)	99 (38.4)	0.12
No	67 (20.6)	9 (13.4)	38 (56.7)	20 (29.9)	
Income (\$)					

	Periodontal Severity n (%)				P Value
	n (% of entire sample)	None/Mild (0)	Moderate (1)	Severe (2)	
0 to 11,000	51 (15.7)	6 (11.8)	30 (58.8)	15 (29.4)	0.75
11,001 to 22,000	60 (18.5)	3 (5.0)	33 (55.0)	24 (40.0)	
22,001 to 33,000	43 (13.2)	5 (11.6)	20 (46.5)	18 (41.9)	
33,001 to 44,000	33 (10.2)	2 (6.1)	21 (63.6)	10 (30.3)	
44,001 to 55,000	31 (9.5)	6 (8.7)	14 (45.2)	11 (35.5)	
>55,000	69 (21.2)	6 (8.7)	35 (50.7)	28 (40.6)	0.03
Unknown	38 (11.7)	2 (5.3)	23 (60.5)	13 (34.2)	
Dental insurance					
Currently has insurance	92 (28.3)	12 (13.0)	54 (58.7)	26 (28.3)	
Does not have insurance	232 (71.4)	18 (7.8)	122 (52.6)	92 (39.7)	
DM					0.47
Has DM	17 (5.2)	1 (5.9)	7 (47.1)	9 (52.9)	
Other family history of DM	116 (35.7)	12 (10.3)	64 (55.2)	40 (34.5)	
No history of DM	192 (59.1)	17 (8.9)	105 (54.2)	70 (36.5)	
Smoker					0.04
Current	52 (16.0)	4 (7.7)	6 (11.5)	22 (42.3)	
Former	60 (18.5)	2 (3.3)	30 (50.1)	28 (46.7)	
Never	213 (64.5)	24 (11.3)	120 (56.3)	69 (32.4)	

Statistically significant associations ($P < 0.05$) listed in bold.

Table 2
Bivariate Relationships Between Demographics of Sample Population Versus Clinical Measures

Entire Sample	Number of Teeth			Bleeding Score			Plaque Score		
	Mean (SD)	Range	P Value	Mean (SD)	Range	P Value	Mean (SD)	Range	P Value
Sex			0.09			0.42			0.56
Males	24.89 (4.25)	8 to 28		16.12 (19.89)	0 to 100		40.19 (23.51)	0 to 100	
Females	25.34 (4.64)	3 to 28		16.43 (18.71)	0 to 86.54		38.31 (22.31)	0 to 100	
Race/ethnicity			0.005			0.17			0.08
Non-Hispanic white	24.98 (4.64)	3 to 28		15.34 (17.71)	0 to 73.96		40.26 (22.91)	0 to 96.88	
Hispanic	26.19 (2.77)	17 to 28		17.49 (21.97)	0 to 100		38.94 (22.85)	0 to 100	
Non-Hispanic black	22.26 (6.59)	5 to 28		23.01 (22.43)	0 to 86.54		46.27 (26.05)	0 to 100	
Non-Hispanic Asian	26.61 (1.97)	22 to 28		11.31 (12.40)	0 to 52.34		29.31 (19.73)	0 to 68.97	
Other/mixed race	25.43 (2.82)	18 to 28		13.11 (19.21)	0 to 85		34.76 (21.53)	0 to 88	
Age (years)			<0.001			0.72			0.26
18 to 24	27.32 (1.38)	24 to 28		14.84 (20.70)	0 to 83.04		34.47 (18.49)	0 to 82.14	
25 to 44	26.54 (2.69)	11 to 28		15.55 (19.49)	0 to 100		37.72 (23.24)	0 to 100	
45 to 64	24.49 (4.40)	8 to 28		17.77 (20.14)	0 to 86.54		42.58 (24.29)	0 to 100	
>64	22.04 (6.55)	3 to 29		14.75 (15.81)	0 to 61.72		37.72 (20.64)	0 to 88.98	
Education			0.001			0.63			0.15
College graduate	26.02 (3.25)	8 to 28		15.66 (18.24)	0 to 85		36.95 (22.09)	0 to 92.86	
Some college	24.63 (5.03)	5 to 28		18.60 (22.23)	0 to 100		43.68 (24.13)	0 to 100	
Grade 12/GED	23.13 (6.00)	3 to 28		12.64 (13.97)	0 to 53.57		38.30 (23.57)	2.34 to 96.88	
<Grade 12	23.43 (3.88)	15 to 28		17.76 (25.17)	0 to 68.75		43.80 (22.05)	10.58 to 88.33	
Spoke English as a child			0.17			0.97			0.97
Yes	24.82 (4.78)	3 to 28		16.26 (19.73)	0 to 100		39.56 (23.64)	0 to 100	
No	26.15 (2.43)	18 to 28		16.26 (17.91)	0 to 70.31		38.74 (20.29)	0 to 81.58	
Income (\$)			0.004			0.33			0.76
0 to 11,000	25.53 (4.17)	11 to 28		16.75 (18.74)	0 to 69.53		39.58 (23.34)	0 to 100	

Entire Sample	Number of Teeth			Bleeding Score			Plaque Score		
	Mean (SD)	Range	P Value	Mean (SD)	Range	P Value	Mean (SD)	Range	P Value
11,001 to 22,000	24.05 (4.64)	8 to 28		20.13 (23.23)	0 to 86.54		40.45 (22.90)	0 to 100	
22,001 to 33,000	25.03 (5.19)	3 to 28		12.68 (16.23)	0 to 73.96		36.92 (23.09)	0 to 80.56	
33,001 to 44,000	25.36 (4.88)	5 to 28		13.89 (15.24)	0 to 54.46		36.73 (22.93)	0 to 88	
44,001 to 55,000	23.39 (5.60)	8 to 28		22.01 (21.68)	0 to 70.31		44.93 (21.70)	0 to 86.61	
>55,000	25.35 (3.57)	11 to 28		15.04 (20.32)	0 to 100		37.45 (23.02)	0 to 100	
Dental insurance			0.003			0.28			0.42
Currently has insurance	25.87 (3.75)	11 to 28		18.60 (20.86)	0 to 83.04		37.57 (22.23)	0 to 100	
Does not have insurance	24.78 (4.66)	3 to 28		15.30 (18.64)	0 to 100		40.06 (23.26)	0 to 100	
DM			0.21			0.42			0.12
Has DM	24.29 (5.05)	8 to 28		21.26 (20.88)	0 to 59.72		45.08 (23.85)	9.38 to 88.89	
Other family history of DM	25.84 (3.35)	10 to 28		13.76 (16.70)	0 to 83.04		41.84 (21.38)	0 to 100	
No history of DM	24.72 (4.89)	3 to 28		17.35 (20.58)	0 to 100		37.26 (23.67)	0 to 100	
Smoker			<0.001			0.97			0.08
Current	23.38 (5.40)	8 to 28		15.19 (16.61)	0 to 59.38		38.55 (23.80)	0 to 100	
Former	24.50 (4.70)	3 to 28		17.77 (21.94)	0 to 83.04		44.78 (23.42)	0 to 88.89	
Never	25.68 (3.96)	5 to 28		16.08 (19.20)	0 to 100		37.98 (22.51)	0 to 100	

Statistically significant associations ($P < 0.05$) listed in bold.

Table 3

Ordinal Logistic Regression of HL Measures Versus PSI

Measures	Total Sample		Periodontal Severity Score					
			Unadjusted			Adjusted*		
	n (%)	Mean (IQR)	OR	Range	P Value	OR	Range	P Value
HL measures								
NVS								
	80 (24.6)	0 to 2 correct	1.00			1.00		
	89 (27.4)	3 to 4 correct	1.36	0.75 to 2.44	0.31	1.14	0.61 to 2.12	0.32
	246 (48.0)	5 to 6 correct	1.94	1.14 to 3.29	0.01	1.22	0.68 to 2.18	0.30
Chew et al. ⁴ screening question (difficulty understanding written materials)	179 (55.1)	None (0)	1.00			1.00		
	77 (23.7)	A little of the time (1)	2.01	1.18 to 3.43	0.01	1.72	0.99 to 3.01	0.056
	69 (21.3)	Some/all of the time (2 to 5)	0.75	0.44 to 1.29	0.29	0.68	0.38 to 1.20	0.18
Short TOFHLA	33.2 (34 to 36)		1.93	1.08 to 3.45	0.03	1.01	0.53 to 1.90	0.98
OHL measures								
REALMD-20	17.4 (17 to 19)		1.17	0.60 to 2.27	0.65	1.48	0.73 to 3.01	0.28
CMOHK	17.5 (16 to 20)		1.34	0.74 to 2.43	0.33	1.45	0.76 to 2.76	0.25

IQR = interquartile range.

Statistically significant associations ($P < 0.05$) listed in bold.

OR is the odds of having a lower (better) PSI, comparing those in the lowest and highest quartiles of HL scores.

* Final adjusted model reflects corrected OR after removing non-significant variables. Adjusted model includes age, sex, and race/ethnicity.

Table 4

Linear Regression Model of HL Measures Versus Epidemiologic Clinical Measures

Measures	Number of Teeth		Bleeding Score (% sites BOP)		Plaque Score (% sites with plaque)	
	95% CI (mean change)	Adjusted 95% CI (mean change)*	95% CI (mean change)	Adjusted 95% CI (mean change) [†]	95% CI (mean change)	Adjusted 95% CI (mean change) [‡]
HL measures (ref.)						
NVS						
0 to 2 correct						
3 to 4 correct	0.88 to 3.85 (2.36)	0.47 to 3.14 (1.80)	-8.88 to 3.44 (-2.72)	-8.84 to 3.42 (-2.71)	-11.50 to 3.20 (-4.15)	-10.93 to 3.39 (-3.77)
5 to 6 correct	P = 0.002	P = 0.008	P = 0.39	P = 0.39	P = 0.27	P = 0.30
	1.72 to 4.47 (3.10)	0.42 to 2.80 (1.61)	-9.17 to 1.82 (-3.67)	-7.90 to 3.34 (-2.28)	-13.05 to 0.43 (-6.31)	-12.56 to 0.67 (-5.94)
	P <0.001	P = 0.008	P = 0.19	P = 0.43	P = 0.07	P = 0.08
Chew et al. ⁴ screening question (difficulty understanding written materials)						
None (0)						
A little of the time (1)	-0.77 to 1.34 (0.29)	-1.39 to 0.73 (-0.33)	-6.31 to 3.46 (-1.43)	-5.88 to 4.43 (-0.73)	-7.42 to 5.42 (-1.00)	-5.44 to 7.79 (1.18)
Some/all of the time (2 to 5)	P = 0.60	P = 0.54	P = 0.57	P = 0.78	P = 0.76	P = 0.73
	-2.18 to 0.49 (0.29)	-1.71 to 0.74 (-0.84)	-2.01 to 9.87 (3.93)	-1.39 to 9.71 (4.16)	-2.48 to 11.17 (4.34)	-1.11 to 12.52 (5.71)
	P = 0.22	P = 0.44	P = 0.20	P = 0.14	P = 0.21	P = 0.10
	1.20 to 3.32 (2.26)	-0.50 to 1.50 (0.50)	-8.22 to 1.72 (-3.25)	-7.87 to 1.85 (-3.01)	-12.20 to -0.27 (-6.24)	-11.55 to -0.05 (-5.80)
Short TOFHLA	P <0.001	P = 0.33	P = 0.20	P = 0.23	P = 0.04	P = 0.048
OHL measures (ref.)						
REALMD-20	0.44 to 3.17 (1.81)	0.66 to 2.94 (1.80)	-10.82 to -0.44 (-5.63)	-5.52 to -0.09 (-5.52)	-15.33 to -1.70 (-8.51)	-15.74 to -1.89 (-8.81)
CMOHK	P = 0.009	P = 0.002	P = 0.03	P = 0.046	P = 0.01	P = 0.01
	-0.16 to 3.32 (1.25)	-0.14 to 2.52 (1.19)	-12.26 to -1.07 (-6.67)	-11.01 to 0.61 (-5.20)	-14.75 to -0.46 (-7.60)	-16.30 to -1.57 (-8.93)
	P = 0.08	P = 0.08	P = 0.02	P = 0.08	P = 0.04	P = 0.02

BOP = bleeding on probing.

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Statistically significant associations ($P < 0.05$) listed in bold.

* Final adjusted model reflects corrected OR after removing non-significant variables using a backward procedure for variable selection at $P < 0.25$ retention criteria. Adjusted model includes age, race, education, smoking, income, and DM.

[†] Adjusted model includes race, dental insurance, and DM.

[‡] Adjusted model includes DM.