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Oral Health Knowledge and Behavior among Adults with Diabetes

Hon K. Yuen, PhD, OTR/L,

Associate Professor, Occupational Therapy Division, Department of Health Professions, College of Health Professions, Medical University of South Carolina, Charleston, SC 29425

Bethany J. Wolf, PhD,

Division of Biostatistics and Epidemiology, Department of Medicine, MUSC, Charleston, SC 29425

Dipankar Bandyopadhyay, PhD,

Assistant Professor, Division of Biostatistics and Epidemiology, Department of Medicine, MUSC, SC 29425

Kathryn M. Magruder, MPH, PhD,

Professor, Department of Psychiatry & Behavioral Sciences, MUSC, Charleston, SC 29425

Carlos F. Salinas, DMD, and

Professor, Director, Division Craniofacial Genetics, College of Dental Medicine, Medical University of South Carolina

Steven D. London, DDS, PhD

Associate Dean for Academic Affairs, Professor of Oral Biology & Pathology, Stony Brook University, School of Dental Medicine, 150 Rockland Hall, Stony Brook, New York 11794-8700.

Hon K. Yuen: yuen@musc.edu; Bethany J. Wolf: wolfb@musc.edu; Dipankar Bandyopadhyay: bandyopd@musc.edu; Kathryn M. Magruder: magrudkm@musc.edu; Carlos F. Salinas: salinasc@musc.edu; Steven D. London: steven.london@stonybrook.edu

Abstract

The purpose of this study was to determine levels of oral health knowledge and factors associated with adequate oral health knowledge in adults with diabetes. A convenience sample of 253 adult US residents with diabetes completed an oral health survey to assess their knowledge. Results showed that only 47% of the participants answered five or more (out of a maximum of seven) oral health knowledge items related to diabetes correctly. Participants who received oral health information related to diabetes have 2.9 times the odds of possessing adequate oral health knowledge (i.e., answered five or more items correctly) compared to participants who did not received that information controlling for education and race (OR = 2.86, 95% CI 1.26–6.24, P = 0.008). Given that oral health information provided by health professionals (dental and/or medical) contributes to improve oral health knowledge among adults with diabetes, health professionals should take the opportunity to educate patients with diabetes about the oral manifestations (e.g., dry mouth) and complications (e.g., periodontitis and oral candidiasis) of diabetes and to promote proper oral health behaviors.

Conflict of interest

The authors declare that they have no conflict of interest.

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Keywords

oral health education; knowledge of oral disease prevention; source of oral health information; periodontal diseases

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Introduction

Periodontitis (a serious, destructive form of periodontal diseases) is recognized as a possible complication of diabetes mellitus [1,2]. Adults with uncontrolled or poorly controlled diabetes have a 3-fold increase in risk for developing periodontitis as compared to their counterparts without diabetes [2–4]. Periodontitis in people with diabetes also progresses more rapidly and becomes more severe compared to that of people without diabetes [2,3,5,6]. Furthermore, uncontrolled or poorly controlled diabetes increases susceptibility to oral opportunistic infections (e.g., oral candidiasis) [1] and contributes to xerostomia [7–9], which can lead to caries, soreness, ulcers, and infections in the mouth [10,11].

Knowledge about susceptibility to periodontal diseases, dry mouth, and prevention of these oral complications, as well as effective management of these conditions for people with diabetes, is therefore important. Research has demonstrated that improving oral health knowledge is a necessary prerequisite for implementation of proper oral self-care behaviors [12]. Although knowledge of correct behaviors does not necessarily translate to practice [13, 14], lack of essential oral health knowledge (e.g., ignorance of the warning signs and symptoms of oral disease) may increase the risks of diabetic oral complications and/or contribute to patients' implementing low levels of oral self-care practices [15,16]. In addition, misconceptions (or incorrect knowledge) about oral health may actually lead to harmful behaviors [17]. For example, instead of brushing and flossing more often, people with diabetes may believe they should stop brushing or flossing when their gums bleed while brushing; or people with diabetes exhibiting dry mouth may not know that using mouth rinse containing alcohol to improve oral hygiene actually increases mouth dryness. These misconceptions and incorrect information about oral health could act as major barriers to efficient prevention and management of oral disease in this high-risk population.

Baseline data on knowledge levels are required to determine which particular areas of oral health education are in need of improvement for this vulnerable population. Determining amendable factors that are associated with adequacy of oral health knowledge is essential to formulate appropriate educational strategies. The importance of oral health-related issues among people with diabetes in the US is based on the fact that the US was ranked third in the number of cases of diabetes in the world [18].

The purposes of this study are to determine levels of oral health knowledge and factors associated with adequate oral health knowledge in adults with diabetes. Specifically, the research questions are: (1) Do adults with diabetes possess adequate oral health knowledge? (2) What are the amendable factors that are associated with adequacy of oral health knowledge in this at-risk group? A cross-sectional survey research design was employed to answer these research questions.

Materials and Methods

Participants

Participants in this study were a convenience sample of 253 adults (age >18 years old) who identified themselves as having diabetes and residing in the US and completed an oral health survey including a section on oral health knowledge. The majority (161 participants, 63.6%)

were recruited from a pool of Gullah-speaking African American adults diagnosed with diabetes in an epidemiological study with subjects drawn from Charleston, South Carolina and surrounding Sea Islands [19,20], and African-American attendants of diabetes education classes in Charleston. The ancestors of the Gullahs were from West Africa, and there has been little immigration of African Americans born elsewhere into the Sea Islands [21,22]. Gullah-speaking African Americans have relatively low European admixture, and high rates of type 2 diabetes, diabetic complications, and periodontitis [21,22]. In addition to the Gullahs, 92 questionnaires were collected from 13 other states, of whom 57 identified themselves as Caucasians and 27 as African Americans. These individuals were recruited from dialysis centers, physicians' offices, and organized community centers using a face-to-face recruitment strategy across the country through a professional recruitment agency.

Procedures

Verbal informed consent was obtained from these participants following an explanation of the study purpose. The study proposal was reviewed and approved by the Institutional Review Board at the Medical University of South Carolina (MUSC). The questionnaire contained a combination of open- and close-ended questions (multiple choice and true/false format). In addition to the socio-demographic information, participants were asked to answer questions related to source of oral health information, oral health knowledge, oral health behavior, dentition status, types of diabetes, years since diabetes diagnosis, and whether they had attended a diabetes education session in the past. Socio-demographic characteristics considered were: age, gender, race, marital status, education, employment status, presence or absence of dental insurance, and annual household income. Oral health behaviors included frequency of dental visits, brushing, flossing, and mouth rinse use.

Administration of the questionnaire was conducted either individually or in small groups. Items and response choices were read to those participants who expressed having difficulty reading (i.e., illiteracy or poor vision).

Oral health knowledge items development

The initial item pool for the oral health knowledge section was assembled based on a review of existing literature related to oral health and diabetes, informal interaction with adults with diabetes, and focus groups from our previous study [17], as well as the clinical experience of three research dental hygienists who have been working solely with adults with diabetes for 2–3 years through a grant funded project, and a behaviorist with expertise in oral health. Items were developed that measured diabetes and oral complications (including oral infections and periodontal diseases), physical signs of periodontal diseases, consequences of periodontal diseases and dry mouth (such as caries, and mouth soreness), and practical components of daily oral self-care to prevent oral complications. Twenty items on oral health knowledge were generated. The response options for these items were: "true," "false," and "don't know." These items were then evaluated by four dental faculty, including a periodontist and a dental epidemiologist, from the College of Dental Medicine, MUSC. These four faculty served to establish the content validity of the items and selected nine items from the pool.

The response to each of the nine items was re-coded as correct or incorrect (including the "don't know" response). These nine items were then refined and validated through exploratory factor analysis (EFA) and item analysis. Principal component factor analysis was used to examine the structure of response patterns and confirm the scale validity. Item analysis includes computation of item difficulty, item discrimination (item-discrimination index [D-index], and corrected item-total correlation/point-biserial correlation) [23]. Item difficulty was measured as the percent of participants who answer the item correctly. A D-index by the method of extreme groups was used to measure the effectiveness of an item in differentiating between

high and low scorers on the whole test. Classification of the high and low scoring groups (i.e., extreme groups) was based on the 27% rule of the whole group [24]. Kuder-Richardson coefficient of reliability (KR-20) was used to estimate the scale internal consistency. The KR-20 is a special version of Cronbach's alpha coefficient for items that are dichotomous.

Psychometric properties of the oral health knowledge items and test

Items were eliminated if they were not associated with a dominant factor [25] and/or if their item-total score correlation coefficients were less than 0.30 [26]. The eigenvalues resulting from the EFA were [2.999, 1.285, 1.044, 0.946, 0.385]. Although some eigenvalues were greater than one (which would indicate that the participants' knowledge could be comprised of more than one latent construct or factor), a scree plot confirmed the strong indication of only one dominant factor. Given this indication of a single factor, items that had factor loading of 0.40 or above on the dominant factor (as indicated by the EFA) were retained [25]. Items that did not meet this criterion were eliminated from the test. At the end of the item reduction phase, seven of the original nine knowledge items were retained. Their factor loading ranged from 0.55–0.72. These seven items were used to define participants' knowledge of oral health (see Table 1)

As indicated in Table 1, the item difficulty of the seven items ranged from 0.30 to 0.88 with an average difficulty level of 0.59, which meant the overall difficulty of the items in the oral health knowledge test is desirable. These items had the D-index ranging from 0.38 to 0.91 with an average discrimination value of 0.74, which meant the strength of the oral health knowledge test to differentiate high and low scorers was very strong. The corrected item-total correlations of these items ranged from 0.39 to 0.56, with an average correlation of 0.50, which meant all the items were moderately correlated with the overall total score of the oral health knowledge test. The internal consistency coefficient of these items was 0.78, suggesting adequate reliability [26].

The readability of the oral health knowledge test was measured by the Flesch/Flesch–Kincaid Readability Tests [27]. The reading level of these items was at the 4th grade and the Flesch Reading Ease score was 85.2 which is in the easy range of reading comprehension.

Data Analysis

Participants were divided into two groups according to their number of correct responses: those above the median (five or more items answered correctly) and those at or below the median (four or fewer items answered correctly). Participants who scored above the median were signified as having adequate knowledge of oral health versus those participants who scored at or below the median who were signified as having inadequate knowledge of oral health. Placing the cutoff at the median is a commonly used method to set the cutoff score in health knowledge tests [28–30].

Knowledge of oral health was modeled to estimate odds for participants having adequate versus inadequate knowledge of oral health. We used nQuery v. 6.0 [31] to calculate the statistical power for the detection of a difference in the proportion of participants with adequate oral health knowledge among those who received information on oral health related to diabetes versus those who did not receive information about oral health and diabetes. For these data, the power to detect an odds ratio of 2.7 was estimated to be 75%.

Potential explanatory variables used in modeling oral health knowledge included socio-demographic characteristics of the participants, type of diabetes (type I or II), years since diabetes diagnosis, attended a diabetes education session in the past (yes vs. no), received instructions from dental health professionals on how to brush and floss teeth since their

diagnosis with diabetes (yes vs. no), and received oral health information related to diabetes from health professionals (yes vs. no).

There were four questions related to oral health information received by participants from health professionals since their diagnosis of diabetes. They were: (1) brush teeth at least two times daily, (2) floss teeth at least once a day, (3) visit a dentist for check up at least two times a year, and (4) diabetes can make your teeth and gums worse. For each question, participants identified the specific health professionals who provided this information since their diagnosis with diabetes. Health professionals included: dentists, dental hygienists, physicians, diabetes educators/nurses, and pharmacists. The responses for each specific health professional in each of the four questions were all found to be significantly correlated (all P-values < 0.001) which would lead to issues of collinearity in a multivariable logistic regression model. Thus, for the multivariable logistic regression analysis, rather than considering the specific health professional providing the information, we considered participants who indicated receiving oral health information from either dental (i.e., dentists or dental hygienists) and/or medical (i.e., physicians, diabetes educators/nurses, or pharmacists) health professionals as having received the oral health information specified in the particular question.

Prior to developing logistic regression models of oral health knowledge, we performed univariate regression analyses using Chi-square tests and Fisher's exact tests (when appropriate) for categorical variables with two levels, Cochran-Armitage trends tests for ordinal categorical variables with more than two levels, and t tests for continuous variables to determine explanatory variables for adequate oral health knowledge. Explanatory variables with a P-value less than 0.25 in univariate models were considered as candidates for multivariable modeling [32].

We used a multivariable logistic regression analysis to model the probability of adults with diabetes having adequate oral health knowledge. All P-values reported in the multivariable models were two-sided, and the type I error rate was set at 0.05. All statistical analyses were performed using SAS version 9.1.

Results

The mean age ($\pm$ standard deviation) for the 253 participants was 57.9 ± 12.8 years-of-age (range 22 to 87 years) with the majority being African Americans (74.3%). Other socio-demographic information is shown in Table 2. Eighty-three percent of participants identified themselves to have type II diabetes. The mean number of years since diagnosis of diabetes ($\pm$ standard deviation) was 13.0 ± 11.5 years (range < 1 to 58 years). More than three quarters (75.5%) of participants reported having taken a diabetic education session to learn managing their diabetes, and 73.1% of the participants reported having told their dentist that they have diabetes.

Twenty participants reported that they were completely edentulous. In terms of oral health behavior, 42.7% of dentate participants reported visiting a dentist for a regular check up (at least once every two years), and 58.6% went to see a dental hygienist last year. Of the dentate participants, 95.3% brushed teeth at least once a day and 61.2% brushed at least twice a day; 34.9% flossed their teeth at least once a day and 35.3% never flossed; 62.1% used mouth rinse at least once a day.

There were significant associations between the proportion of participants who had attended diabetic education sessions on how to manage their diabetes and the proportion of participants who received oral health information (i.e., brush teeth at least two times daily, floss teeth at least once a day, visit a dentist for check up at least two times a year, and diabetes can make your teeth and gum worse) from the diabetes educators/nurses (all P-values < 0.001).

Table 3 shows the percent of participants who reported having received oral health information from various health professionals. For the information that diabetes can make your teeth and gums worse, 50.6 % of participants reported that they received this information from dentists, 47.0% from physicians, 46.6% from diabetes educators/nurses, 41.1% from dental hygienists, and 6.3% from pharmacists.

Oral health knowledge items

The mean and standard deviation of the number of oral health knowledge items answered correctly by participants was 4.1 ± 2.0 . The median of the number of oral health knowledge items answered correctly was four. The number of participants who achieved adequate oral health knowledge—defined as above the median of items answered correctly (i.e., five or more items)—was 47%. No significant difference between the proportion of African Americans and other race/ethnic group (Caucasian and Hispanic) was found in the achievement of adequate oral health knowledge, nor was there a significant difference in the number of items answered correctly. However, among the seven oral health knowledge items, the item “If your gums bleed every time you brush your teeth, it’s an early sign of gum disease” was answered correctly by a larger proportion of African Americans than the other race/ethnic group ($P = 0.014$).

Factors affecting oral health knowledge among adults with diabetes

Results of the univariate analyses indicated that adequate oral health knowledge had a statistically significant relationship with the following variables: responses to the four questions related to oral health information (i.e., brush teeth at least two times daily, floss teeth at least once a day, visit a dentist for check up at least two times a year, and diabetes can make your teeth and gums worse) received from health professionals; and having received instructions from dental care providers on how to brush and floss teeth since their diabetes diagnosis (all P -values < 0.01). The responses to the four questions related to oral health information were all highly correlated (all P -values < 0.001); therefore, they were combined into a new variable: whether or not an individual had received information related to diabetes. The questions were combined such that if an individual answered yes to one or more of the four questions, that individual was considered as having received oral health information related to diabetes. The responses to this new variable were used in constructing the multivariable logistic model.

Employment status was the only socio-demographic variable that was significantly associated with oral health knowledge, with employed participants being more likely to have adequate oral health knowledge ($P = 0.049$). Whether or not a participant had dental insurance was not significantly associated with having adequate oral health knowledge ($P = 0.234$).

Results of the final multivariable model indicated that having received oral health information related to diabetes was the only factor significantly associated with adequate oral health knowledge controlling for education and race. Participants who received oral health information related to diabetes had 2.9 times the odds of demonstrating adequate oral health knowledge compared to participants who did not receive that information controlling for education and race (OR = 2.86, 95% CI 1.26–6.24, $P = 0.008$) (see Table 4).

Results of the univariate analyses for the African American subgroup were similar to the results of the whole group. African American participants who reported receiving oral health information related to diabetes had 2.3 times the odds of answering at least five of the oral health knowledge items correctly compared to those who did not receive such information controlling for education (OR = 2.29, 95% CI 0.95–5.54, $P = 0.067$). The results are marginally significant and the trend is the same as the whole study population.

Since the majority of the African American participants were members of the Gullah population in South Carolina (85.6%) and thus represented a more uniform group [21,22], a separate analysis of this group for factors influencing oral health knowledge was also conducted. The results for the univariate and multivariable analyses of the Gullah subgroup were in agreement with the analysis of all African American participants.

Association between oral health information received and oral health behaviors

There was no significant association between the proportion of participants who had adequate oral health knowledge and the proportion of participants who had regular dentist visits for check ups, went to visit a dentist in the past 12 months, brushed teeth at least two times daily, or flossed teeth at least once a day. However, there were consistent trends between specific oral health information received from health professionals and the specific self-reported oral health behaviors among dentate participants. Among dentate participants: those who were told to have a dental check up at least 2 times a year were in fact more likely to visit a dentist in the past 12 months ($P = 0.002$), or visit a dentist for regular check-ups (at least once every two years) ($P = 0.016$); those who received information on brushing teeth at least two times daily were more likely to brush teeth at least twice daily ($P = 0.006$); and those who received information on flossing teeth at least once daily were more likely to floss teeth at least once daily ($P = 0.016$).

Discussion

Results of this study show that more than half of the participants did not have adequate oral health knowledge related to diabetes. These findings are consistent with studies conducted worldwide including some in developing countries [33–38].

Table 1 reveals that participants are most knowledgeable on the signs and consequence of gum disease (with more than 80% of them answering those questions correctly), and least knowledgeable on the effect of dry mouth on oral health (with about 30% of them answering those questions correctly). Knowledge about susceptibility to oral infections and complications among people with diabetes is moderate (with slightly less than 50% answering this question correctly). The proportion of participants who are aware of the relationship between diabetes and periodontal diseases seems higher than that reported in the literature (about 67.6% in this study vs. 17.0% to 41.6% in the literature) [33–38]. This may be attributed to the increase in oral health information received in this area from health professionals (see Table 3). For example, compared to reports in the literature of less than 45% of adults with diabetes being informed of the relationship between diabetes and periodontal diseases by one or more types of health professionals [33–37,39], in our study 70% of participants reported that they have received this information.

Within the last decade, the alarming increase in adults diagnosed with diabetes in the US, coupled with the discovery of periodontitis as a possible complication of diabetes mellitus, have increased awareness of health professionals on the importance of educating patients on the relationship between oral health and diabetes [40–42]. As indicated in the multivariable model, adequate oral health knowledge among the participants was associated with oral health information they received from health professionals (dental and/or medical). In addition, we found a significant relationship between those who attended a diabetes education session and the oral health information they received from the diabetes educators/nurses. Consistent with Manz et al's [39] findings, dentists, physicians, diabetes educators, and dental hygienists are the key health professionals who provide information to their patients on the relationship between diabetes and periodontal diseases.

The majority of previous studies used only one item (the relationship between oral health and diabetes) to assess oral health knowledge [33–37]. Taiwo [38] designed several items assessing oral health knowledge related to oral complications and diabetes, including the causes of periodontal diseases, vulnerability of those with diabetes to periodontal diseases, and the need for glycemic control in the prevention and control of oral infections. However, no psychometric properties for these items were provided, nor did the study include details on item development [38].

Our item and scale analyses provide evidence to support the validity and reliability of the oral health knowledge test to estimate participants' general understanding of periodontal diseases, and oral manifestations and complications associated with diabetes. The finding of no association between adequate oral health knowledge and oral health behaviors may be attributed to the fact that typical oral health behaviors (dental visit in the past 12 months, brushing twice daily, and flossing daily) do not reflect information the participants received. This is supported by our findings that oral health information provided by health professionals will help improve oral health knowledge among adults with diabetes, and the significant association between a particular area of oral health information received and frequency of engaging in oral health behaviors being specific to the corresponding information received. Future studies should ask participants to report oral health behaviors that match the content of an oral health knowledge test. For example, questions that focus on situational oral hygiene behavior, such as frequency of brushing when encountering bleeding after brushing, may be more appropriate.

Limitations

We acknowledge that the sample in this study is a convenience sample which may or may not represent the diabetes population. Nevertheless, it should be noted that oral health behaviors in the present study are similar to those reported in the literature [43]. For example, 58.6% of the dentate participants in this study had an annual dental visit in the past year which is comparable to that reported by 60.7% (95% CI 57.7–63.6) of dentate adults in the 2003 National Health Interview Survey [43]. Our finding of no significance difference in oral health knowledge between the African Americans or Gullahs and the rest of race/ethnic group participants from different states seems to provide some evidences of external validity on this study sample. Another potential limitation is the use of only close-ended questions (i.e. yes/no/don't know) in the oral health knowledge test may allow participants to guess the correct answer.

Implications

Health professionals have the opportunity to educate patients with diabetes about oral manifestations (e.g., dry mouth) and complications (e.g., periodontitis and oral candidiasis) of diabetes and to promote proper oral health behaviors. They should provide appropriate special oral care information and advise concerns related to dental hygiene. In addition to the routine education of patients with diabetes about the importance of proper oral hygiene and receiving regular professional dental care, health professionals should educate patients about oral complications related to diabetes and measures that can be taken to prevent these oral complications such as avoiding tobacco use.

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Table 1

Percent of participants who correctly answered the seven oral health knowledge items

Items	Whole group (N=253)	African Americans (n=188)	Caucasians/Hispanics (n=65)
People with diabetes are more likely to have infection in their mouth.	48.2	46.8	52.3
People with diabetes are more likely to have gum disease.	66.4	66.5	66.2
Diabetes can make one's teeth and gums worse.	68.8	67.6	72.3
People with dry mouth are more likely to have a sore in the mouth.	30.4	29.3	33.8
People with dry mouth are more likely to have tooth decay.	32.0	35.1	23.1
If your gums bleed every time you brush your teeth, it's an early sign of gum disease.	77.9	81.9*	66.2*
Gum disease can lead to loss of teeth.	88.1	86.7	92.3

* Note. $p < 0.05$ for percent of African Americans vs. percent of Caucasians/Hispanics answering this item correctly

Table 2

Demographic information (N=253)

Characteristic	Percent
Race	
African American	74.3%
Caucasian	22.5%
Hispanic	2.8%
Gender (Female)	70.8%
Married	47.0%
Education beyond high school	40.3%
Employment (full- and part-time)	34.8%
Dental insurance	54.5%
Income (US\$)	
< \$15,000	41.5%
\$15,000–\$29,999	25.7%
\$30,000–\$44,999	11.4%
≥ \$45,000	21.3%

Table 3

Percent of participants (N=253) who have received oral health information from dental and/or medical health professionals since they were diagnosed with diabetes.

Oral Health Information	Dentists	Dental Hygienists	Dental Health Professionals	Physicians	Diabetes Educators / Nurses	Pharmacists	Medical Health Professionals
Brushing teeth at least 2 times a day	54.2%	48.6%	62.8%	41.5%	41.1%	8.3%	52.2%
Flossing teeth at least once a day	55.3%	51.4%	63.6%	29.6%	32.4%	6.3%	42.3%
Dental check up at least 2 times a year	55.7%	44.7%	60.1%	44.7%	43.5%	8.3%	55.3%
Diabetes can make teeth and gum worse	50.6%	41.1%	56.5%	47.0%	46.6%	6.3%	57.3%

Note. Dental health professionals include dentists and dental hygienists. Medical health professionals include physicians, diabetes educators/nurses, and pharmacists.

Table 4

Univariate and multivariable analyses examining factors associated with adequacy of oral health knowledge in adults with diabetes (N=253)

Predictor	Reference Category (adequate knowledge)	Univariate Analysis			Multivariable Analysis		
		OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Race	Caucasian/other	0.84	(0.47, 1.46)	0.529	0.87	(0.49, 1.55)	0.647
Education	High school or less	1.37	(0.83, 2.28)	0.218	1.37	(0.81, 2.29)	0.238
Received oral health information related to diabetes	Have not received information	2.73	(1.26, 5.90)	0.011	2.86	(1.31, 6.24)	0.008
Received brushing and flossing instruction from dental health professionals	Have not received brushing and flossing instruction	2.66	(1.60, 4.41)	<.001			
Employment status	Not employed for wages	1.69	(1.03, 2.93)	0.049			

Note. Inadequate knowledge = answer fewer than 5 items correctly