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Influence of knowledge, attitudes, and behaviors of added sugars consumption on periodontal status in low-income women

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Abstract

Background: Periodontitis is a chronic inflammatory disease caused by interactions between bacterial infection and host response. Nutrition education plays an important role in preventing oral health diseases and related problems. The present research will assess oral hygiene practices, nutrition knowledge, attitudes, and behaviors related to added sugars, within the context of periodontal disease in low-income women.

Methods: A pre-validated Dental Nutrition Attitudes, Beliefs, and Behaviors questionnaire was distributed among 220 low-income women. Periodontal disease was measured using clinical attachment loss and probing pocket depth. One-way ANOVA, linear, and multivariate logistic regression were utilized for analysis.

Results: Linear regression analysis exhibited significant positive associations of knowledge with attitude ($r = 0.190$, $P = 0.000$), and behavior ($r = 0.298$, $P = 0.000$), as well as attitude with behavior ($r = 0.542$, $P = 0.000$) of the low-income women. Women who scored higher on knowledge subscale were less likely to be in stage 2 [OR $= 0.21$, 95% CI: 0.008–0.582, $P = 0.002$] and 3 [OR $= 0.32$, 95% CI: 0.009–0.916, $P = 0.021$], as compared to the lower stage. Those who scored higher on the attitude and behavior subscales were less likely to be in stage 2 [OR $= 0.191$, 95% CI: 0.066-.0559, $P = 0.003$ vs OR $= 0.501$, 95% CI: 0.172–1.461, $P = 0.046$] and 3 [OR $= 0.178$, 95% CI: 0.051–0.620, $P = 0.007$ vs OR $= 0.215$, 95% CI: 0.062–0.744, $P = 0.015$] than in stage 1.

Conclusions: Significant limited dental nutrition attitude, belief, and behavior regarding periodontal disease were observed. Health care professionals and dentists should provide nutrition counseling about periodontal disease during health care delivery visits.

Keywords: Dental nutrition, Attitudes, Beliefs, Behaviors, Periodontal disease, Low-income women

Background

Periodontitis is a chronic inflammatory disease caused by interactions between bacterial infection and host response (Pihlstrom et al. 2005) that affects tissues around the teeth, including gums, periodontal ligaments, and the alveolar bone. Periodontal disease is closely linked to other health conditions such as cardiovascular disease (Humphrey et al. 2008), diabetes (Taylor and Borgnakke 2008), and adverse pregnancy outcomes (Xiong et al. 2006). The prevalence in the USA is widespread, as it occurs in almost half of individuals, ages ≥ 30 years (Eke et al. 2012). Women experience higher risks for oral health problems than men due to fluctuating sex hormones (Mariotti and Mawhinney 2000; Martelli et al. 2017). It is of particular importance to women, as research suggests that severe periodontal disease raises the probability of preterm and low birthweight infants (Corbella et al. 2016; Ide

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and Papapanou 2013). Finally, individuals with lower income or education levels are at higher risk for periodontal disease (Borrell and Crawford 2000; Borrell et al. 2006).

Risk behaviors for periodontal disease include irregular tooth brushing (Litonjua et al. 2003), flossing (Greene 1963), lack of dental visit (Stokes 2005), and frequent intake of food with added sugars (Lula et al. 2014). In a study by Lang et al., brushing, flossing, and dental visit frequency were all associated with lower plaque, gingivitis, and calculus scores (Lang et al. 1995). Furthermore, the dietary component of added sugars is also believed to influence periodontal disease through its stimulation of inflammation (Calder et al. 2009). Added sugars are the caloric sweeteners added to foods and beverages during cooking or manufacturing, primarily to enhance palatability, consistency, and texture (Erickson and Slavin 2015). Studies indicate that a higher intake of added sugars is associated with parameters of periodontal disease, including an increase in probing pocket depth (PPD) (Cheraskin et al. 1965), clinical attachment loss (CAL) (Yoshihara et al. 2009), and bleeding on probing (BOP) (Sidi and Ashley 1984).

Low-income individuals are particularly vulnerable to diets high in added sugars, as they live in poverty-stricken areas with numerous fast food stores that sell sugary foods and sugar-sweetened beverages (Evans et al. 2015). These foods with high added sugars may be popular in this economic group, as these foods are generally inexpensive and highly palatable (Wisman and Capehart 2010). Furthermore, food deficiency has been suggested to function as a stressor that increases preferences for high-sugar (Wisman and Capehart 2010). Thus, public health interventions to reduce periodontal disease should involve strategies to increase nutrition knowledge and positive attitudes, and behaviors.

Nutrition education plays an important role in preventing oral health diseases and related problems (Badrasawi et al. 2020a). A number of health behavior theories suggest that improving nutrition knowledge and attitudes can stimulate dietary behaviors that promote good health (Sanjeevi et al. 2017; Lang et al. 1990; Sweeting et al. 2008). Although general nutrition knowledge, attitude, and behaviors relating to periodontal disease have been evaluated, none have incorporated added sugars as a primary focus (Kelly and Moynihan 2008; Badrasawi et al. 2020b; Sajjan et al. 2015).

The present research will assess oral hygiene practices, nutrition knowledge, attitudes, and behaviors related to added sugars, within the context of periodontal disease in low-income women.

Methods

Study design

In this cross-sectional study, 222 women were recruited from low-income housing communities. The participants completed a demographics questionnaire (Clarke et al. 2007); Food Frequency Questionnaire; Dental Nutrition Knowledge Competency Scale (Sachdev et al. 2020); Dental Nutrition Attitudes, Beliefs, and Behavior Scale (Babaei et al. 2019) and were screened for periodontal assessment on one visit. Periodontal examinations of the mouth were performed by a registered dental hygienist (RDH) in order to evaluate the status of periodontal disease. Indicators used included clinical attachment loss (CAL) (López et al. 2001) and periodontal pocket depth (PPD) (Hefti 1997). A compensation of $20 was given as an incentive. All questionnaires were made available in English and Spanish. Participation in the study was voluntary, and written informed consent was obtained. This research was approved by the Institutional Review Board at The University of Texas at Austin and conducted in full accordance with ethical principles of the World Medical Association Declaration of Helsinki (version 2008) (Babaei et al. 2019).

Sample

The sample consisted of 222 low-income women (annual income < 250% of the Federal Poverty level) (Alaimo et al. 2001), 18 to 50 years of age, who had received dental treatment in the last five years. These women were recruited from June to December 2018 from low-income housing units. The minimum sample size was based on G-Power (Faul et al. 2009) (version 3.1.2), yielding power of 95%, with a medium effect size of 0.30 for regression analysis. Women who were pregnant, lactating, enrolled in weight loss programs during the prior six months, smoking, or had a systemic illness were excluded, as these increase the risk of periodontal disease. Also, enrollment in graduate school was an exclusion in order to avoid bias from advanced education. These women were recruited from June to December 2018 from low-income housing units.

Demographics

A 13-item demographics questionnaire was used to collect information on age, ethnicity, annual household income, household size, and registration in food assistance programs (Clarke et al. 2007).

Food frequency questionnaire (FFQ)

An adapted version of a 95-item FFQ measured the intake of added sugars (Sanjeevi et al. 2017). This questionnaire has been validated previously for use in low-income women in the Central Texas area. Two food items

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of dried fruits and energy drinks were added to the original questionnaire in order to obtain more information on added sugars. Previously, the 95-item FFQ was validated against a 3-day dietary recall in low-income women. Mean validity correlation was 0.61; the test–retest correlation was 0.66. Serving size choices of the FFQ were small, medium, large, and extra-large. Questionnaire options ranged from never, or less than once per month, to 2+times per week. Images and quantities per serving were used to help participants estimate portion sizes. Data on the consumption of the following foods, which are the main sources of added sugars in US diets, were extracted: cakes, cookies, and brownies; ice cream, and milkshakes; chocolate candy and fudge; ready-to-eat cereals; and fruit drinks, regular colas, and sodas. Then, added sugars intake were computed by multiplying the number of servings consumed for each food item by frequency of consumption. Dietary data were analyzed for nutrients using FoodWorks17 software (Long Valley, NJ).

Dental nutrition knowledge competency scale

An adapted version of a validated and reliable dental nutrition knowledge questionnaire was used to evaluate nutrition knowledge related to added sugars in low-income women (Sachdev et al. 2020). The scale demonstrated good internal consistency ($\alpha = 0.7 \pm 0.014$) and test–retest reliability ($r = 0.8 \pm 0.015$, $p < 0.01$). The 12-item multiple-choice scale measured knowledge of added sugars in foods and on food labels, and the recommended frequency of oral hygiene practices. Each item scored from 0 to 1, except question 12, which had a possible score from 0 to 3. The answer to each item was summed to calculate total scores, with highest score 12, and the lowest score, 0. A higher score on this scale implied greater dental nutrition knowledge toward added sugars.

Dental nutrition attitudes and behavior questionnaire

A 9-item scale of dental nutrition attitudes and behavior was used in order to assess dental nutrition attitudes and behavior regarding added sugars (Babaei et al. 2019). This questionnaire was previously validated in low-income women. It exhibited good internal consistency (0.80), with a test–retest reliability of 0.99. Each item was scored on a five-point Likert scale that ranged from strongly disagree (score 1) to strongly agree (score 5). Individual answers of items in each subscale were computed to obtain total scores and mean scores. The highest score was 45, and the lowest score was 9. A higher score on this scale implied more positive dental nutrition attitudes and behaviors toward added sugars.

Periodontal assessment

A registered dental hygienist measured periodontal status by dental examinations in all present teeth, except for the third molars. The extent of periodontal disease was measured by the clinical attachment loss (CAL) (López et al. 2001), probing pocket depth (PPD) (Hefti 1997), and bleeding on probing (BOP) (Lang et al. 1990). The CAL reveals the severity of the periodontal disease, defining the amount of space between the attached periodontal tissue and the cementoenamel junction. Measurement of distance from the cementoenamel junction to pocket depth was defined by the CAL score (Sweeting et al. 2008). If no recession was observed, two mm was subtracted from the probing depth score, as tissues are normally about 2 mm above the CEJs (Wei and Lang 1981). In recession situations, the amount of recession was added to the probing depth. The PPD is the space from the gingival edge to the base of the gingival crevice that is measured via a periodontal probe (Williams, West Chester, PA). A pocket under 3 mm deep was designated as being healthy; while 4 mm was considered unhealthy. The PPD ranged from 1 to 6 mm. Six sites were measured for PPD and CAL per tooth for all teeth, except the third molar (Sweeting et al. 2008). BOP was described as bleeding that occurred at any of the six sites during 30 s of probing (Royzman et al. 2004).

Periodontal disease was categorized into four stages, based on the new classification of the 2017 World Workshop on Classification of Periodontal and Peri-Implant Diseases and Conditions (Caton et al. 2018). This classification categorizes periodontal disease as stage 1: (CAL 1–2 mm, PPD ≤ 4, and no tooth loss); stage 2 (CAL 3–4 mm, PPD ≤ 5, and no tooth loss); stage 3 (CAL ≥ 5, PPD ≥ 6, and ≤ 4 teeth loss); or stage 4 (CAL ≥ 5, PPD ≥ 5, and ≥ 5 teeth loss).

Statistical analysis

Analyses were performed using SPSS version 22.0 (SPSS Inc., Chicago, IL). One-way ANOVA analysis, with periodontal severity stages as the dependent variable, was used to compare sociodemographic variables between the stages of periodontal disease. Multivariate logistic regression was conducted to examine associations of knowledge, attitudes, and behaviors for consumption of added sugars with severity of periodontal disease. Stage 1 of periodontal disease was considered as the reference group, after adjustment for age, ethnicity, education level, income, flossing, and tooth brushing as potential confounding variables. Also, linear regression analysis assessed the relationship of knowledge, attitude, and behavior. Finally, the Preacher and Hayes (2004) mediation model 166 was performed to

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investigate relationships of dental nutrition knowledge, attitudes, and behaviors with periodontal disease, after adjusting for consumption of added sugars intake. A second mediation analysis was carried out with the same variables, but was adjusted for demographics. Total, direct, and indirect effects were examined in the mediation model.

Results

A total of 222 subjects completed the Dental Nutrition knowledge and Attitudes and Behavior questionnaires and were assessed for periodontal status. The demographics and periodontal-related characteristics of the respondents are summarized in Table 1. The average age was 35.13 ± 8.5 yr, and the majority were Hispanic (59.89%), with less than a high school degree (45.48%) and an annual income of $< \$25,000$ (63.05%). Most participants brushed their teeth twice a day (65.34%) and flossed once daily (49.08%). All participants exhibited periodontal disease, with a CAL mean value of 1.742 ± 0.75. The majority were in stage 1 (43.4%), with 39.4% in stage 2, and 17.2% in stage 3. However, no one was in stage 4, so it was eliminated from this study.

Knowledge regarding dental practices and added sugars

Individuals scored less than 50% of the maximum possible score on each question, denoting low dental nutrition knowledge regarding added sugars. The average score on this scale was 7.21, out of a possible score of 12. Less than half of the participants (45.49%) correctly chose four common market beverages with added sugars and about one-quarter could identify four added sugar products. More than half (60%) knew that flavored yogurt contains added sugar. Two-third of participants were not aware of the new 2015–2020 US Dietary Guidelines about recommended amounts of added sugar in the diet (60%) and did not know that added sugar was a requirement for the revised nutrition label (67.6%). Participants were cognizant of oral health practices, with over half aware of the recommendation to brush two times/day and to visit a dentist twice a year. Yet, 64% did not know that one should floss daily. In terms of food labeling, more than half of the respondents incorrectly answered the amount of added sugars per serving listed on the sample of the food label. Also, they were unable to identify the percent daily value of added sugar in one serving of the sample product. Additionally, about 60% of women could not list the second main ingredient in the sample food product

Table 1 Demographic characteristics of low-income women based on periodontal disease severity, Central Texas, June–December 2018 (*n* 222) [†]

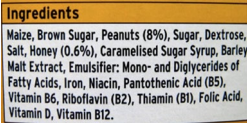| Characteristics	Periodontitis, *n* (%)			P value*
	Stage			
	1	2	3	
Age, yr				
18–25	18 (8.10)	14 (6.30)	6 (2.70)	
26–35	26 (11.71)	23 (10.36)	15 (6.75)	0.011
36–50	52 (23.42)	50 (22.52)	18 (8.10)	
Race/Ethnicity				
Hispanics	58 (26.12)	54 (24.32)	21 (9.45)	
African/American	14 (6.30)	14 (6.30)	9 (4.05)	
Non-Hispanic Whites	16 (7.20)	10 (4.50)	7 (3.15)	0.030
Other	8 (3.60)	9 (4.05)	2 (0.90)	
Education				
< High school	46 (20.72)	39 (17.56)	16 (7.20)	
High school graduate	26 (11.71)	20 (9.00)	11 (4.95)	0.001
> High school	24 (10.81)	28 (12.61)	12 (5.40)	
Annual Income, $				
< 25,000	51 (22.97)	61 (27.47)	28 (12.61)	
25,000–34,999	20 (9.00)	14 (6.30)	3 (1.35)	
35,000–49,999	9 (4.05)	10 (4.50)	6 (2.70)	0.010
50,000–60,000	16 (7.20)	2 (0.90)	2 (0.90)	
Tooth brushing, day				
1	24 (10.81)	16 (7.20)	15 (6.75)	
2	63 (28.37)	60 (27.07)	22 (9.90)	0.985
≥ 3	9 (4.05)	11 (4.95)	2 (0.90)	
Flossing, day				
0	29 (13.06)	30 (13.51)	15 (6.75)	
1	48 (21.62)	41 (18.46)	20 (9.00)	
2	16 (7.20)	14 (6.30)	4 (1.80)	0.170
≥ 3	3 (1.35)	2 (0.90)	0 (0.00)	

*Significant at *P* value < 0.05

[†] One-way ANOVA

and more than three-quartiles of respondents did not correctly name the added sugars in that sample food product (Table 2).

Attitudes regarding dental practices and added sugars

The average score on the attitude subscale was 15 out of 25. Approximately half of the participants disagreed with the statements that "I prefer drinking milk rather than soda" (50.60%), "I try to visit a dentist even if I do not have pain in my mouth" (48.8%), and "If I eat added sugar products, I may increase the risk of gum disease" (48.2%) statements. However, less than half agreed that one should avoid foods with added sugar (43.2%%) or

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Table 2 Correct answers and mean scores of knowledge questions (*n* 222)*

Knowledge of added sugars	Correct answers,%	Mean ± SD†
Added Sugars Which of these market foods contain added sugars? *Orange drink from 5% juice, cranberry juice cocktail, orange soda, lemonade*	45.49	0.26 ± 0.22
Which food products usually contain added sugars? *Canned fruits in heavy syrup, barbeque sauce, salad dressing, frozen pizza*	26.12	0.27 ± 0.173
Which food item contains added sugar? *Flavored yogurt*	59.90	0.47 ± 0.01
US dietary guidelines and food labeling guidelines		
According to US Dietary Guidelines of 2015–2020, the amount of added sugar one consumes should be_____ percent of the total daily calories? *≥ 10*	40.09	0.48 ± 0.03
Which item is required by the newly revised 2016 US nutrition facts label? *Added sugars*	32.43	0.43 ± 0.17
According to this food label, how many grams of ADDED sugar does one serving of this product contain? *10 gr*	48.19	0.49 ± 0.37
According to this nutrition facts label, what % Daily value (DV) for added sugars does one serving of this product provide? *20%*	47.29	0.78 ± 0.17
What is the second main ingredient in this food product? *Brown sugar*	42.34	0.49 ± 0.32
List the added sugars in this food product? *Brown sugar, sugar, dextrose, honey, caramelized sugar syrup, malt extract*	1.80	2.09 ± 0.02
Oral hygiene practices		
What is the recommended number of times one should BRUSH every day? 2 times per day	50.45	0.46 ± 0.22
What is the recommended number of times one should FLOSS? *1 time per day*	36.06 53.60	0.49 ± 0.17
What is the recommended number of times one needs to visit a dentist? *Two times a year*		0.49 ± 0.33

*Score ranges from 0–1 for every question except the last question which is from 0–3

† Total possible score is 14

those high in carbohydrates such as pasta, white bread, rice (36.9%) (Table 3).

Behaviors regarding dental practices and added sugars

The behavior subscale had an average score of 12.98, out of a possible score of 20. Almost half of the participants disagreed that they should "drink water rather than soda" (45.3%) or "read food labels before buying products" (51.6%). But the majority agreed that they "brush two

Table 3 Mean scores and frequency distributions of attitudes and behaviors regarding periodontal disease (*n* 222)*

	Mean Score†	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Percentage						
Attitudes						
How much do you agree with the following statements?						
I prefer drinking milk rather than soda	2.82	20.60	30.00	16.10	11.70	21.20
I try to visit a dentist even if I do not have pain in my mouth	2.80	34.50	14.30	9.40	18.80	22.40
I avoid food with added sugars	3.29	11.20	13.50	32.00	21.6	21.60
I avoid foods high in carbohydrates such as pasta, white bread, rice	3.13	11.30	21.60	30.20	17.10	19.80
If I eat added sugar products, I may increase the risk of gum disease	2.96	21.60	26.10	12.60	13.50	26.10
Behavior						
How much do you agree with the following statements?						
I drink water rather than soda	3.01	19.70	25.60	14.80	19.30	20.20
I usually brush two times a day	3.61	10.30	18.40	8.50	24.20	38.10
I read food labels before buying products	2.80	22.90	28.70	13.50	13.90	20.60
I go to the dentist once a year	3.56	16.20	8.50	12.10	28.70	34.10

*Total possible score of attitude scale and behavior scales are 25 and 20, respectively

† Mean score was calculated using scores assigned to responses from strongly disagree (score 1) to strongly agree (score 5)

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times a day" (62.3%) and "go to the dentist once a year" (62.80%) (Table 3).

Relations regarding dental nutrition knowledge, attitudes, and behaviors with periodontal disease

Linear regression analysis indicated significant positive associations of knowledge with attitude ($r = 0.190$, $P = 0.000$), and behavior ($r = 0.298$, $P = 0.000$), as well as attitude with behavior ($r = 0.542$, $P = 0.000$) of the low-income women.

Women who scored higher on knowledge subscale were less likely to be in stage 2 [OR = 0.21,

95% CI: 0.008–0.582, $P = 0.002$] and 3 [OR = 0.32, 95% CI: 0.009–0.916, $P = 0.021$], as compared to the lower stage. Those who scored higher on the attitude and behavior subscales were less likely to be in stage 2 [OR = 0.191, 95% CI: 0.066-0.0559, $P = 0.003$ vs OR = 0.501, 95% CI: 0.172–1.461, $P = 0.046$] and 3 [OR = 0.178, 95% CI: 0.051–0.620, $P = 0.007$ vs OR = 0.215, 95% CI: 0.062–0.744, $P = 0.015$] than in stage 1 (Table 4).

Mediation effect of added sugars intake

A mediation analysis examined if added sugar intake mediates the associations of dental nutrition knowledge, attitudes, and behaviors with periodontal disease, after adjusting for demographics (Fig. 1). The total effect of dental nutrition knowledge, attitudes, and behaviors on the periodontal disease was significant ($\beta = - 0.1130$ ($P < 0.05$) (Fig. 1a). The effect was reduced, but remained significant, after added sugar intake was incorporated as a mediator ($\beta = - 0.0415$ ($P < 0.05$) (Fig. 1b). The indirect effect was significant, as the confidence interval did not include a 0 ($- 0.0536$ to $- 0.0047$).

Discussion

The results of this study suggest that lower scores on dental nutrition knowledge, attitude, and behaviors regarding added sugars were associated with a higher severity of the periodontal disease. The findings also indicate that attitude, low knowledge, and poor lifestyle choices were

Table 4 Associations between dental nutrition knowledge, attitudes, and behaviors and periodontal disease in low-income women (*n* 222), Central Texas, June–December 2018[†]

Periodontal disease severity[‡]				
Variable[§]	Stage 2		Stage 3	
	OR[‖] (95% CI)	P value*	OR (95% CI)	P value*
Knowledge	0.21 (0.008 0.582)	0.002	0.32 (0.009–0.916)	0.021
Attitude	0.191(0.066–0.559)	0.003	0.178 (0.051–0.620)	0.007
Behavior	0.501 (0.172–1.461)	0.046	0.215 (0.062–0.744)	0.015

[†] Multivariate logistic regression

[‡] The reference category is stage 1. Stage 4 was excluded as it contained only one individual
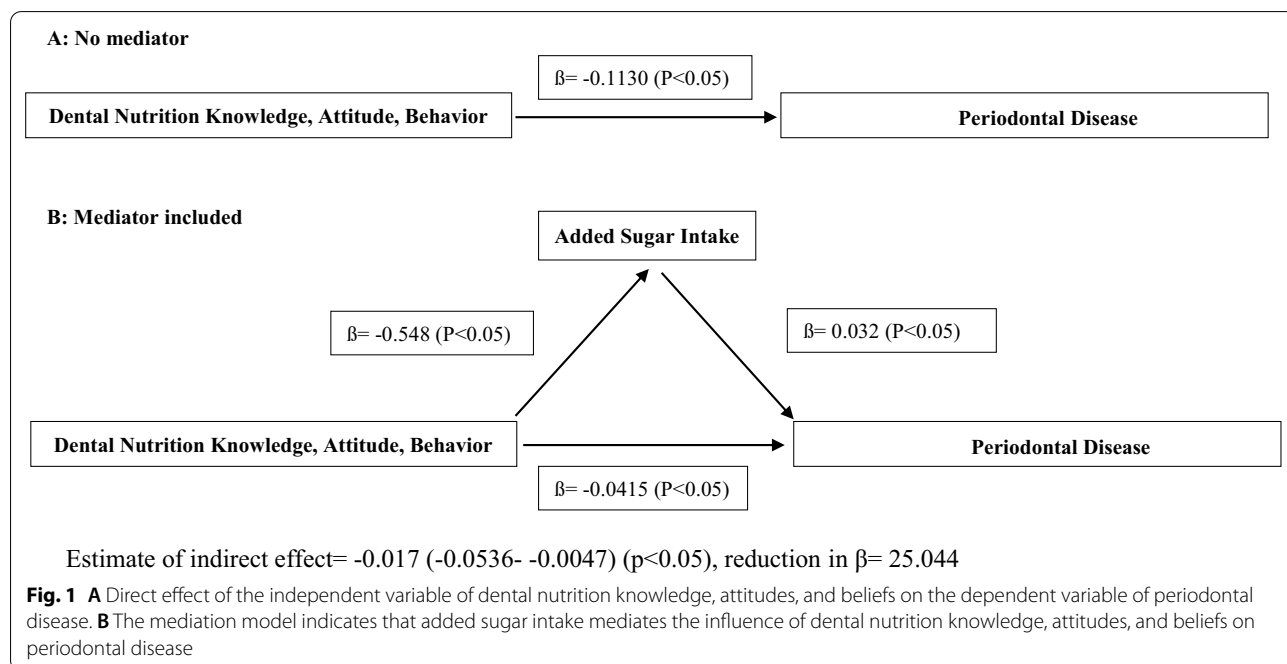
[§] Categorical variables were dummy-coded in order to reduce collinearity

[‖] Odds ratio

*Significant at *p* value < 0.05

Estimate of indirect effect= -0.017 (-0.0536- -0.0047) (p<0.05), reduction in β= 25.044

Fig. 1 **A** Direct effect of the independent variable of dental nutrition knowledge, attitudes, and beliefs on the dependent variable of periodontal disease. **B** The mediation model indicates that added sugar intake mediates the influence of dental nutrition knowledge, attitudes, and beliefs on periodontal disease

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related to greater sugar intake in the diet. Although some participants exhibited a positive attitude for avoiding added sugars, it did not appear to change behavior. These results are in line with work by Tanveer et al. (2018), who found that positive attitudes are neither preventive nor health-promoting. The low knowledge about added sugars observed may reflect lack of avoidance of sugar intake. Thus, education programs in the underserved should emphasize the role of added sugars on periodontal health as part of the curriculum.

Previously, investigations of oral health nutrition knowledge, attitudes, and behaviors have sampled health professionals (Kelly and Moynihan 2008; Faine and Oberg 1995). In the present study, those with low incomes were the population utilized. For example, Faine et al. assessed the knowledge of cariogenic foods and practices in dental hygienists and nutritionists (Faine and Oberg 1995). Both groups accurately rated the frequency of food retentiveness in the mouth and snacking as important dietary factors in the development of the oral disease. In 2008, Kelly et al. investigated dental practitioners and hygienists to discern attitudes toward the role of nutrition in periodontal health (Kelly and Moynihan 2008). The majority of the dentists (66%) believed that nutrition plays an important role in periodontal health. Critical factors cited for the development of periodontal disease were oral hygiene, smoking, genetic predisposition, alcohol, and frequency of sugar consumption. In a study of Nigerian dental students, the majority of participants (70%) demonstrated knowledge about the types of sugar-sweetened beverages and potential health conditions (Fadupin 2014). In the current study, those with low incomes also exhibited poor knowledge about the effect of added sugars in the diet. This finding is in contrast with Xu et al. (2020), who suggested that the knowledge gap is strongly associated with geographical area and accessibility to education facilities. Yet, the current research was conducted in Austin, Texas, an area which has good accessibility to public educational situations and free internet hot spots. But, it may prove difficult for those with limited income to translate knowledge into behavior if one cannot afford to buy healthier food (Gordon 2002). Whether the tendency of the low-income to buy high sugary foods is based on taste or necessity is unclear (Badrasawi et al. 2020b).

The present research found a positive association between nutrition knowledge and use of the food labels. It is unknown if nutrition knowledge increased the use of food labels or the food labels had improved nutrition knowledge. In 2018, Wilson et al. reported that low-income Latinos had a lower likelihood of reading nutrition labels, as compared to those with higher-income (Wilson et al. 2018). The current research suggests that individuals may look at the sugar information on food labels, but they may not know which items are sugars. This situation may be particularly true when multiple and complex scientific names are listed on the label. In the current research, ingredients such as dextrose, honey, caramelized sugar syrup, and malt extract were not identified as sugars by almost all (98.2%) of the participants. This finding is similar to a study located in the United Arab Emirates (Khawaja et al. 2019). Undergraduate students were not familiar with different names of sugar on nutrition labels, especially fructose and sucrose. They assumed that monosodium glutamate was an added sugar. This lack of knowledge concerning the identification of added sugars in the educated suggests a need to continue to emphasize knowledge of added sugars for consumers.

The present research observed that greater knowledge of dental nutrition was associated with more positive nutrition attitudes and behaviors. This finding confirms previous research by Marietta et al. which recognized that increasing one's knowledge in nutrition improves attitudes and behavior toward a healthy diet. In college students at Missouri State University, nutrition knowledge score was found to be positively correlated with attitudes toward nutrition labels and use of labels (Marietta 1999).

In oral health practices, the majority (50.45%) of participants knew the recommended frequency of brushings and had positive behaviors regarding brushing teeth. These results are in agreement with Lian et al.(2010) who assessed oral health knowledge, attitude, and practices in secondary school students in Malaysia . A positive attitude regarding dental services and tooth brushing was observed, but behavior did not seem to correspond, as a majority (71.3%) failed to visit the dentist frequently. In intermediate and high school students in Saudi Arabia, most (87%) were cognizant that tooth brushing helps prevent periodontal disease, but only one-third were aware that dental flossing was helpful as well (Farsi et al. 2004).

The model for the present study found that that relationships between dental nutrition knowledge, attitudes, and behaviors and periodontal disease were mediated, partially by the intake of added sugars. This result is consistent with that of Thomas et al., who queried dental students about knowledge, attitude, and consumption of sugar-sweetened beverages (Madiba et al. 2017). Students with poor nutrition knowledge and attitudes consumed significantly more added sugars ($P < 0.01$) than those with higher dietary levels. In contrast, in 2019, Schafer et al. did not find any relationships between knowledge and attitude and the amount of added sugars that were consumed in adults in the USA (Schafer- 2019).

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Limitations

A limitation of this research is that the cross-sectional nature of this study does not indicate causality. Also, since the participants were Hispanic women, generalizability may be limited to other ethnic/racial groups. Ideally, future research should test the knowledge, attitudes, and behaviors of added sugar and dental practices in larger, more diverse populations. The model utilizing knowledge, attitudes, and behaviors suggests that knowledge and attitude shape one's behavior. However, this theory does not explain the complicated nature of behavior or account for external influences. Similarly, cultural variations may play a crucial role in shaping food choices. Culture must be a critical component in future clinical and public health interventions, especially in areas with large immigrant populations (Additional file 1).

Conclusions

This research found inverse relationships between dental nutrition knowledge, attitudes, and behaviors and periodontal disease in low-income women. It demonstrated the mediating effect of added sugar intake on these relationships. A greater understanding of the psychosocial factors regarding diet–disease relationships and how knowledge, attitudes, and behaviors help improve diet is necessary for inducing positive change. The greater accessibility of foods with high added sugars in impoverished areas may act as major barriers to healthy eating. Thus, public health interventions need to consider strategies to raise awareness of the effects on added sugars and the availability of healthy foods in low-income areas.

Abbreviations

PPD: Probing pocket depth; CAL: Clinical attachment loss; BOP: Bleeding on probing.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s42269-022-00868-z.

> **Additional file 1.** STROBE Statement—checklist.

Author contributions

M.B. designed the study, conducted data collection and statistical analysis, and contributed to writing of the manuscript. J.F.G. contributed to the design, data collection, and writing of the manuscript. P.K.S. contributed to the design, data collection, and analysis of the study. G.W. contributed to the design, data collection, and analysis of the study. All authors have read and approved the manuscript.

Availability of data and materials

Not applicable.

Declarations

Ethical approval and consent to participants

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and the study was approved by the Institution of Review Board, the University of Texas at Austin. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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