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Development and validation of the Dental Nutrition Knowledge Competency Scale for low-income women

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Abstract

Objective: To develop and validate a Dental Nutrition Knowledge Competency Scale to assess dental health-related nutrition knowledge of low-income women.
Design: This is a cross-sectional study. A literature search for foods/dietary practices related to dental caries was conducted and the items were incorporated into an initial questionnaire. A panel of ten nutrition experts evaluated it for its content, readability and relevance, and a focus group of six low-income women determined its readability and comprehension. Then the questionnaire was administered to 150 low-income women. Construct validity was evaluated by item difficulty, item discrimination and factor analysis. Internal consistency reliability was tested via Cronbach's α. In a sub-sample of forty women, test–retest reliability was established. Paired-sample *t* tests were conducted to examine differences between test scores at the two time points, 2 weeks apart.
Settings: Community centres in low-income housing in Central Texas, USA.
Participants: A total of 150 low-income women, aged 18–50 years; annual household income <250 % of the federal poverty level.
Results: Item difficulty and discrimination analysis resulted in elimination of eight questions. Factor analysis identified twenty-four items that loaded on three factors related to knowledge. These included foods/dietary practices that affect dental caries, added sugars in foods and on food labels, and recommended frequency of oral hygiene practices. The subscales and the completed scale exhibited good internal consistency (mean 0·7 (SD 0·97)) and test–retest reliability (mean 0·8 (SD 0·013)).
Conclusions: The Dental Nutrition Knowledge Competency Scale is a validated and reliable instrument to assess nutrition knowledge related to dental health in low-income women.

Keywords
Dental nutrition knowledge
Cariogenic foods
Added sugars
Food labels

Dental caries is a microbial disease which is characterized by dissolution and decalcification of tooth structure[1]. In the USA, 91 % of adults aged 20–64 years have caries in their permanent teeth and 27 % suffer from untreated dental decay[2]. According to the global burden study of 2010, untreated caries in the permanent dentition was the most prevalent condition among the 291 diseases included in the analysis[3]. Dental caries exhibited a global presence of 35 % for all ages combined[3]. Dental caries also accounted for a significant number of years lost due to disability or ill-health[3].

Striking economic disparities exist in the prevalence of dental disease by income, with the greatest prevalence in economically disadvantaged populations[4]. Data from the National Health and Nutrition Examination Survey have documented an inverse association between income and the prevalence of dental caries in children and adolescents[4]. In adults, the prevalence of caries also differs by race/ethnicity, with a higher prevalence of untreated dental caries in Hispanic (36 %) compared with non-Hispanic White (22 %) and Asian (17 %) adults[2]. Finally, women experience a greater risk of developing caries in comparison to men, due to differences in salivary flow rate and hormonal variations[5]. Dental caries develops when bacteria in the plaque break down sugars in foods to produce acids, which can further cause demineralization of the tooth surface[6]. Diets are important in the prevention of this process, as foods high in sugars[7], low in dairy[8] and fruit and vegetables[9] have been linked with a greater risk of this microbial disease. In a recent

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longitudinal study of 1702 adults aged 30 years or older, a positive dose–response relationship was documented between the amount of sugars consumed and dental caries, which remained significant even after adjustment for the daily use of fluoridated toothpaste[10].

The present paper focuses on low-income adults as they often have diets high in added sugars[11] and fats and low in whole grains, vegetables and fruits[12]. One reason for the increased consumption of sugar-sweetened beverages in recent years may be a lack of nutrition knowledge in this economic group[13]. Previous studies have reported a positive association between knowledge and consumption of sugars[14,15]. In a study in Australian adults, a significant reduction in the quantity and timing of sugar intake was documented in patients who received nutrition counselling by the dental practitioner[15].

In addition to sugars, other retentive, non-sugary fermentable carbohydrates also may pose a significant risk for dental caries[16]. These include foods such as savoury snacks, processed grains, breads, acidic sodas and fruit juices. Other dietary factors/practices play a critical role in the development of dental caries. These include the consistency and form of food (liquid, solid, sticky, retentive, low oral clearance), combination of foods eaten, timing of sugar consumption (between or with meals), frequency of snacking, and frequency and total amount of sugar consumed[16].

Added sugars are sugars that are integrated into foods or beverages during processing[17]. The US Dietary Guidelines of 2015–2020 restrict the consumption of added sugar to <10 % of total daily energy intake. Lack of knowledge on dietary guidelines for sugars has been documented in other countries. In a recent study of university students and staff in Northern Ireland by Tierney *et al.*, it was found that 65 % of the population lacked knowledge on the WHO guidelines on added sugars[18]. No study to date has determined the knowledge on added sugar guidelines and interpretation of sugars on food labels in low-income individuals in the USA.

Previous studies have reported positive associations between nutrition knowledge and use of food labels[19,20]. Analysis of the 1994–1996 Continuing Survey of Food Intakes by Individuals (CSFII) found that the energy intake from added sugars was 1·1 % less in those who used sugar information on food labels compared with non-users[21]. In 2016, the Food and Drug Administration introduced new food labels that included an 'Added Sugars' component on the nutrition facts panel[22]. Although this information is provided on food labels, the low-income consumer may fail to interpret and identify the amount and types of hidden sugars present.

In addition to diet, knowledge on optimum oral hygiene practices of toothbrushing and flossing is critical, as these practices remove harmful bacterial colonies from the tooth surface. The American Dental Association recommends brushing twice daily with fluoridated toothpaste, and flossing at least once daily, to remove plaque and food particles between the teeth[23]. Collectively, lack or inadequate knowledge on adverse foods, dietary practices and oral hygiene recommendations may increase the risk of development of dental caries. Overall, knowledge of cariogenic foods, added sugar guidelines, food labels and the recommended frequency of oral hygiene practices may play a major role in reducing the development of dental caries.

Previously, few investigations have used instruments to measure nutrition knowledge related to dental caries. In a cross-sectional study of 139 nutritionists and dental hygienists, Faine and Oberg evaluated the knowledge of foods and dietary factors that contribute to dental caries[24]. Then in 2016, Bapat *et al.* developed an instrument to measure nutrition knowledge related to oral health in nutritionists/dietitians[25]. Both these studies are excellent, but the populations studied were health professionals who may be more cognizant about nutrition than low-income individuals. A self-structured questionnaire by Venkatesan and Taj assessed the amount of consumption of cariogenic foods and oral hygiene practices in a sample of the general population in India (n 100)[26]. This questionnaire was created and tested for those of Indian origin, who have different dietary habits compared with US residents. We are not aware of any research which has assessed nutrition knowledge related to dental caries in a low-income population.

Studies have utilized validated tools to measure the construct of dental health literacy[27]. This is the capability of an individual to understand basic oral health information in order to effectively navigate the health-care system. This type of literacy is more focused on the treatment, rather than the preventive aspect, of dental caries. Previously, instruments have been tested for comprehension[28–32], numerical interpretation[29,33,34] and recognition of dental terminologies[30,34–39]. The target populations for the instruments have varied, such as patients attending dental clinics, college students, pregnant and caregiver mothers, the elderly and young children. However, no instrument exists that captures nutrition knowledge related to oral health in low-income women. The aim of the current research was to develop a questionnaire to assess nutrition knowledge related to dental caries in low-income women.

Methods

Development of scale

Figure 1 describes the process of development and validation of the Dental Nutrition Knowledge Competency Scale. A detailed review of the literature on the relationship between diet and dental caries was conducted from 1950 to 2018. Items were selected and incorporated into a forty-two-item scale to measure dental nutrition knowledge. Questions were developed at a 6th-grade reading level. A panel of ten nutrition experts evaluated the initial

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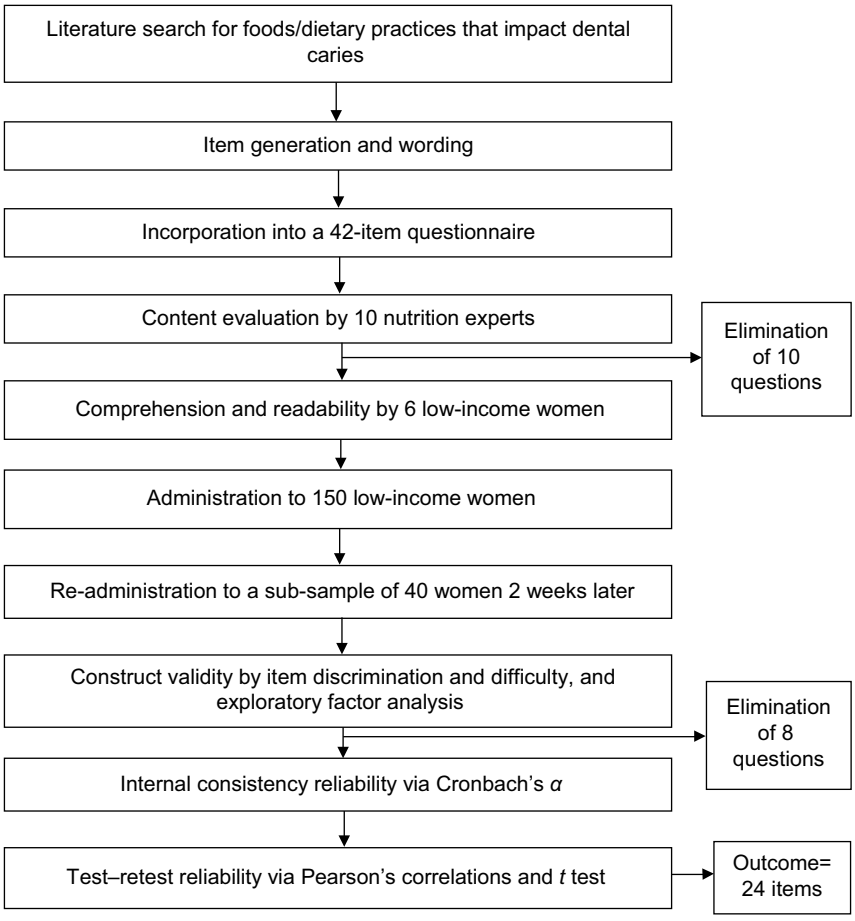

Fig. 1 Flowchart of the development and validation of a Dental Nutrition Knowledge Competency Scale for low-income women

instrument for its readability, relevance, item difficulty, content and bias. Then, a focus group of six low-income women was utilized to assess readability and comprehension. Feedback and suggestions from the panel of nutrition experts and the focus group were used to create the final version of the questionnaire. The questionnaire was created in both English and Spanish.

Sampling method

This is a cross-sectional study of 150 women recruited from low-income housing units, recreation centres, online posts and by word of mouth. The housing is maintained by Foundation Communities, an organization that provides low-income housing reserved for individuals with an income ≤50 % of the median family income ($US 41 280 for a family of four in 2018)[40] published by the Texas Department of Housing and Community Affairs[41].

The US federal poverty level (FPL) in the year 2018 was $US 25 750[42]. Individuals with income < 200 % of the FPL (annual income ~ $US 51 500) were classified as low-income[42]. Thus, the recruitment of the sample from this housing suggests that our participants were low-income. Flyers for the research were distributed at doorsteps of the apartments, community centres, recreation centres and laundry rooms of the low-income housing units. The flyers contained details of the study, inclusion and exclusion criteria for the research, contact information of the researchers, and time and location where the research booth would be set up in the community centres. No participants were recruited from community centre dental clinics which cater to low-income people, in order to avoid the bias of selecting people who were already cautious about their oral health.

The recruitment team consisted of English- and Spanish-speaking individuals. All questionnaires were available in both languages and written at a 6th-grade level. The participants were informed about the risks and benefits of the study and a written consent was obtained from those who expressed an interest to participate. At one visit, the women completed a demographic survey and the Dental Nutrition Knowledge Competency Scale. A compensation of $US 5 in the form of a gift card was provided. Contact information was obtained for those who expressed interest in completing the instrument at a second time point. A sub-sample of forty women completed the scale at the second point of time, 2 weeks later, to establish test–retest reliability. All questionnaires and informed consents were kept

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in a locked cabinet in a locked office. Data were de-identified and coded as subject numbers on the data sheets and questionnaires.

Sample

Participants were 150 low-income women (annual income < 250 % of the FPL), 18–50 years of age, who had received dental treatment in the last 5 years. Pregnant, lactating and those enrolled in graduate school or participating in weight-loss programmes during the prior 6 months were excluded. These women were recruited from June to July 2018 from low-income housing units and recreation centres.

Demographic survey

A slightly revised version of a demographic questionnaire created by the corresponding author was administered[43]. The survey collected information on the age, ethnicity, education level and annual household income of the participant.

Dental Nutrition Knowledge Competency Scale

The instrument comprised thirty-two questions that tested nutrition knowledge on the following topics: foods/dietary practices that affect dental caries; added sugar dietary guidelines; identification and interpretation of added sugars in foods and on food labels; and the recommended frequency of oral hygiene practices. The format of the questionnaire was multiple-choice questions, with six responses per question. The first ten questions had more than one correct answer, while the remaining twenty-one questions had only one correct answer. The last question was an open response question. The maximum score for each item was 1; the minimum score was 0. Instructions were bolded for both sections and the researchers reiterated the instructions during the administration of the questionnaire.

For the first ten questions and the last question, selection of 50 % or more correct options was denoted a score of 1, while selection below 50 % was scored as 0. The remaining questions had one correct answer, so a score of either 0 or 1 was given. Each multiple-choice question was designed to test one specific nutrition knowledge concept[44]. All questions and responses were independent of one another to avoid providing a cue for another question[44].

Statistical analyses

Statistical analysis was performed via the statistical software package IBM SPSS Statistics version 20.0 and the software Mplus version 8.1. Descriptive statistics were performed on the demographic characteristics to determine percentage distribution of age, race/ethnicity, education level and annual income level.

Validity

Content validity was established by a panel of ten nutrition experts from the Department of Nutritional Sciences at the University of Texas. Factor analysis with weighted least squares with means and variance estimator was used to identify underlying latent variables and constructs in the instrument[45]. The analysis was conducted using both IBM SPSS Statistics and Mplus[46].

Item difficulty analysis

Previous literature has documented that those questions which are answered correctly by more than 80 % or less than 20 % of participants are considered easy and difficult questions, respectively[47]. Therefore, this criterion was used to remove or retain the questions from the instrument.

Item discrimination analysis

Item discrimination analysis is a statistical technique of correlating scores on each item to the total score on the instrument[48]. An item to total correlation of 0·25 or greater was used to retain or remove a question from the questionnaire[49].

Factor analysis with weighted least squares with means and variance estimator was conducted using Mplus software version 8.1. The Mplus software provides four parameters of model fit: the χ^2 test *P* value, comparative fit index (CFI), Tucker–Lewis index (TLI) and root-mean-square estimate of approximation (RMSEA)[50]. The χ^2 test evaluates the relationships between the sample and implied covariance matrices[50] such that an insignificant χ^2 test of model fit indicates good model fit. The CFI compares a target model with a null model, with values above 0·90 indicating good model fit[50]. The TLI is used often for small sample sizes, with values above 0·90 illustrating a good fitting model[51]. The RMSEA is a measure of how well the proposed model would fit the population covariance matrix[50]. A cut-off value for RMSEA close to 0·05 has been considered acceptable for model fit[50]. The confidence interval and probability values for RMSEA were also obtained.

Reliability

The Kuder–Richardson Formula 20 was applied to measure internal consistency. Scores were interpreted as a Cronbach α, which indicates the extent of relatedness between a group of items that measures the same construct. Cronbach's α was used to measure internal consistency or the extent to which a group of items measure the same construct. This internal consistency reliability was measured separately for the different constructs on the instrument, as each section considered a different area of nutrition knowledge. Values of Cronbach's α above 0·7 are considered acceptable for a measurement scale[52]. Test–retest reliability is an important measure of the consistency of the instrument over time. It is critical to measure this statistic in a self-administered instrument where there is minimal involvement of the researcher[53]. Paired-sample *t* tests were conducted to

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examine for differences between test scores at the two time points, 2 weeks apart. A Bonferroni correction was applied[54]. The *t* tests were tested for significance at the Bonferroni critical value.

Results

Participant characteristics

Demographic characteristics of the 150 participants who completed the instrument are shown in Table 1. Age of the participants ranged from 18 to 50 years, with a mean age of 36·31 years. The majority of the sample was Hispanic and had a high-school degree. The majority of the participants (93·4 %) in the present study were low-income with an annual income below 200 % of the FPL (income < $US 51 500), while 6·6 % of people were between 200 and 230 % of the FPL (income = $US 50 000–60 000).

Table 1 Demographic characteristic of a sample of low-income women (*n* 150) from Central Texas, USA, enrolled in a validation study of a twenty-four-item Dental Nutrition Knowledge Competency Scale, June–July 2018

Characteristic	Mean or *n*	SE or %
Age (years), mean and SE	36·31	9·43
Race/ethnicity, *n* and %		
White	32	21·3
Hispanic	81	54·1
African American	20	13·3
Asian	11	7·3
Other	6	4·0
Education level, *n* and %		
Less than 7th grade	15	10·0
Junior high school	24	16·0
Partial high school	17	11·3
High-school graduate	44	29·3
Partial college	36	24·0
College/university graduate/professional	14	9·4
Annual income level ($US), *n* and %		
<25 000	98	65·3
25 000–34 999	19	12·7
35 000–49 999	23	15·4
50 000–60 000	10	6·6

Scores on Dental Nutrition Knowledge Competency Scale

Table 2 shows the mean scores obtained by the participants on the different subscales of the Dental Nutrition Knowledge Competency Scale. For each subscale, the mean score was approximately one-half of the maximum possible score on that subscale. A similar pattern was also observed for the total score obtained on the complete questionnaire.

Item trimming

A forty-two-item questionnaire was created initially, then ten questions were removed after review by an expert panel. Items removed were not suited to measure knowledge of the concepts (*n* 5), were too difficult for this population (*n* 2) or had a biased connotation (i.e. foods that promoted dental caries; *n* 3). The questionnaire was pre-tested in a focus group of six low-income women before administration to the final sample. The pre-testing of the instrument aided in reducing the random error associated with participant characteristics such as literacy and language comprehensibility. The statistical analysis of item difficulty and item discrimination further eliminated eight questions such that the final validated questionnaire consisted of twenty-four items.

Validity

Content validity was established from evaluation by a panel of ten nutritionists. The item difficulty index resulted in the removal of one question which was answered correctly by more than 80 % of the people and the removal of four questions which were correctly answered by less than 20 % of the participants. A total of five questions were removed

Table 2 Mean scores and reliability estimates on the Dental Nutrition Knowledge Competency Scale subscales for a sample of low-income women (*n* 150), Central Texas, USA, June–July 2018

			Reliability *t* test		
Dental Nutrition Knowledge Competency subscale	Mean	SE	α†	*r*‡	*t*§
Diet and dental caries	5·37	0·374	0·716	0·811*	0·892^{NS}
Foods that promote/protect against dental caries					
Dietary practices that promote/protect against dental caries					
Sugars on foods and food labels	5·07	0·797	0·710	0·824*	0·771^{NS}
Identification of foods with added sugars					
Identification/interpretation of sugar information on food labels					
Oral hygiene recommendations	1·02	0·109	0·705	0·810*	0·656^{NS}
Frequency of brushing/flossing					
Number of dental visits/year					
Complete scale	11·46	1·284	0·737	0·842*	1·834^{NS}

*Statistically significant at $P < 0·05$.
†Cronbach's α coefficient (*n* 150; a value ≥ 0·7 is considered acceptable for a measurement scale).
‡Pearson's correlation coefficient between item scores (*n* 40).
§*t* Test on scores from time point 1 and 2; obtained from test–retest sample (*n* 40).

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based on difficulty analysis, and three questions with an item–total score correlation of less than 0·25 also were eliminated. Factor analysis with weighted least squares with means and variance estimator resulted in three constructs: (i) knowledge of foods/dietary practices that affect dental caries; (ii) knowledge of added sugars in foods and on food labels; and (iii) knowledge of the recommended frequency of oral hygiene practices. The item loadings on the three constructs in the scale are presented in Table 3. The parameters of model fit, χ^2 test *P* value, CFI, TLI and RMSEA are presented in Table 4. These results show that the proposed model exhibited a good fit, as demonstrated by the χ^2 test *P* values (non-significant), CFI and TLI (values above 0·9) and RMSEA (values below 0·05).

Table 3 Factor loadings of items on the Dental Nutrition Knowledge Competency Scale on the three constructs

Item	Diet and dental caries	Sugars on foods and food labels	Oral hygiene recommendations
1	0·661*	0·085	0·010
2	0·520*	0·283	0·012
3	0·609*	0·453	0·018
4	0·583*	0·498	0·104
5	0·248	0·423*	0·012
6	0·169	0·397*	0·002
7	0·560*	0·025	0·226
8	0·050	0·751*	0·185
9	0·129	0·370*	0·166
10	0·356*	0·222	0·050
11	0·280*	0·047	0·002
12	0·010	0·544*	0·118
13	0·598*	0·269	0·058
14	0·075	0·460*	0·160
15	0·332*	0·071	0·178
16	0·001	0·318*	0·168
17	0·425*	0·048	0·102
18	0·155	0·014	0·257*
19	0·018	0·139	0·476*
20	0·001	0·018	0·595*
21	0·095	0·441*	0·060
22	0·264	0·392*	0·125
23	0·090	0·494*	0·194
24	0·149	0·396*	0·077

*Significant at $P < 0·05$.

Reliability

Intercorrelations between test items on different subscales of the Dental Nutrition Knowledge Competency Scale were established via Cronbach's α[55], with all subscales in the acceptable range (mean 0·7 (SD 0·97))[52] (Table 2). Test–retest reliability measures showed good reliability, as indicated by the significant correlations (mean 0·8 (SD 0·013)) between the scores at time points 1 and 2 ($P = 0·05$; Table 2). Bonferroni corrections were applied to control for family-wise error. Paired-samples *t* tests were performed between the scores at time points 1 and 2. No significant differences existed at the Bonferroni critical value. This confirmed the consistency of the scale over time.

Discussion

The present research documented that a valid and reliable questionnaire was created that measured dental health-related nutrition knowledge in a low-income population (the final validated scale is provided in the online supplementary material). Low-income women were the sample targeted since they are at a greater risk than men of developing caries due to endocrinological differences[5].

The items for the questionnaire were selected based on a literature review of the relationship between diet and dental caries. The review found scientific evidence on food items that promoted caries and those that were protective

Table 4 Construct validity analysis of the Dental Nutrition Knowledge Competency Scale among a sample of low-income women (*n* 150), Central Texas, USA, June–July 2018†

	Construct validity							
Dental Nutrition Knowledge Competency subscale	No. of factors	Best-fit model‡	*P* value	CFI§	TLI‖	RMSEA¶	90 % CI	*P* value
Diet and dental caries Foods that promote/protect against dental caries Dietary practices that promote/protect against dental caries	1	36·365	0·359	0·994	0·990	0·022	0·001, 0·540	0·936
Sugars on foods and food labels Identification of foods with added sugars Identification/interpretation of sugar information on food labels	1	25·180	0·509	1·000	1·004	0·000	0·000, 0·490	0·952
Oral hygiene recommendations Frequency of brushing/flossing Number of dental visits/year	1	22·246	0·451	0·932	0·900	0·010	0·000, 0·030	0·923
Complete scale	3	210·740	0·415	0·991	0·988	0·011	0·000, 0·037	0·998

†Exploratory factor analysis with weighted least squares with means and variance estimator.
‡χ^2 value from χ^2 test for theoretical model ($P > 0·05$, rejection of null indicates good fit).
§Comparative fit index (a value > 0·90 indicates good model fit).
‖Tucker–Lewis Index (a value > 0·90 indicates good model fit).
¶Root-mean-square error of approximation (a value < 0·05 indicates good model fit).

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against caries. In addition, the relationship between diet and caries is confounded by dietary factors such as the timing of eating sweets, and the consistency and combinations of foods eaten[16]. The purpose of this instrument was to assess the knowledge about the relationships of these foods and dietary factors to dental caries. In the response options, foods were presented in different consistencies, forms and combinations in order to focus more on the practical applications, rather than the theoretical knowledge of the concept.

Previous studies have documented that sugars play a major role in causing dental caries[56,57]. Yet, it is the form of the sugars consumed, as well as total amount, that is important. In the USA, the consumption of added sugars increased by 35 % from 1978 to 1996 in Americans aged ≥2 years[58]. At present, the energy intake from added sugars is still greater than the recommended level of a maximum of 10 % of daily energy intake, especially among low-income groups[17,59]. Thus, the present research explored whether low-income women were cognizant of the oral health effect of added sugars, the amounts in commonly consumed foods and the identification from food labels. Recently, the US government has made efforts to reduce the consumption of added sugars by introducing the 2015 added sugar dietary guideline and the 'Added Sugar' component on food labels. Consequently, two questions determined whether the women were aware of these guidelines. Considering the important role of optimum oral hygiene practices in reducing dental caries, a few questions were included to test knowledge on recommendations for oral hygiene practices.

The design of the twenty-four-item instrument was multiple choice, with more than six response items per question. This design served an important purpose. Nunnally and Bernstein have documented that the probability of guessing the correct answer is reduced considerably (0·16) when the number of response options is increased to six or more[52]. This helped to reduce the error associated with guessing correct responses by the participants[60]. In addition, the distractors or the incorrect options were selected to be similar in length, style and grammar[61]. This design ensured discrimination between people who were knowledgeable about the concept from those who were not[61]. The research team worked closely with the participants, reiterating the instructions, to avoid the random errors associated with misinterpretation. In addition, the questionnaires were checked thoroughly once completed to avoid errors associated with accidentally skipping a test item.

Upon examination of each construct, an acceptable Cronbach's α (mean 0·7 (SD 0·97)) for items within each construct was observed, implying unidimensionality within the constructs. Therefore, combining items within a unidimensional scale should mitigate measurement error[52]. Cronbach's α also helps to calculate the error variance by squaring the correlation and subtracting it from 1. In the present research, the Cronbach's α values achieved for the three constructs were 0·716, 0·710 and 0·705, resulting in error variance of 48·7, 49·5 and 50·2 %, respectively[62]. Previously, Nunnally and Bernstein suggested that in the early stages of research, reliabilities of 0·70 or higher are sufficient[52] and increasing reliabilities beyond 0·80 often results in little attenuation of measurement error[60].

Exploratory factor analysis resulted in three major constructs as discussed above. The first statistics obtained were the χ^2 test of model fit, for which each construct showed a non-significant test as indicated by $P > 0{\cdot}05$[50]. This supported the null hypothesis that there was no difference in the observed data and the hypothesized factor models for each construct and the entire scale. The entire observed data were supported by a three-factor model. The next statistics obtained were the incremental fit indices of CFI and TLI; these indicate the proportionate improvement in fit by the target model relative to a null model (model in which the variables are assumed to be uncorrelated)[63]. Values that approach 1 indicate an acceptable fit[63]. The CFI and TLI values obtained for each construct in our model were greater than 0·90 for each one-factor construct and the entire three-factor model, indicating good fit. The TLI value for the construct of sugar on foods and food labels was 1·004. However, TLI is a non-normed fit index; therefore, values are not restricted to the 0–1 range and it is mathematically permissible for them to be >1[63].

The CFI and RMSEA values for the same construct were 1·00 and 0·000, respectively, indicating an excellent model fit. Such values are often seen in just-identified models, where the number of free parameters is equal to the number of known values, resulting in zero degrees of freedom. However, we had non-zero degrees of freedom, which indicated that it was not a just-identified model. One reason why we could have obtained these results was that the χ^2 statistic for this model was less than the degrees of freedom.

The RMSEA assesses how well a model replicates the data obtained from the sample[50]. Values below 0·05 reported herein indicate a good-fitting model. The RMSEA values obtained were below 0·05 for the one-factor constructs and three-factor entire model. The 90 % CI and the probability for RMSEA also were calculated. The width of the confidence interval usually indicates the precision of RMSEA measurement. The lower value of the 90 % CI included a zero or was very close to zero, while the upper value was not very large (>0·08). The probability values test the null hypothesis that RMSEA is less than 0·05. For all constructs and the entire scale, we failed to reject the null, indicating a good model fit.

The responses obtained on this instrument could not be correlated with scores on any other established instrument. This is because the type of population studied in the present research is unique and differs from those studied by other similar instruments. A previous study by Faine and Oberg developed a survey to measure dental-related nutrition knowledge in dental hygienists and nutritionists[24]. This

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instrument was reviewed by nutrition administrators and dental health consultants and pre-tested in eight nutrition graduate students[24]. Bapat *et al.* developed an instrument (Cronbach's $\alpha = 0{\cdot}80$, content validity ratio = 0·87) to measure knowledge among nutrition/dietetics students about the effect of diet and nutrition on dental health[25]. However, these instruments are limited for use in the general population, who often have less knowledge than health professionals. The present research provided the first instrument that could assess nutrition knowledge related to oral health in low-income women.

Several studies have used validated instruments to measure the construct of dental health literacy. The Rapid Estimate of Adult Literacy in Dentistry (REALD-30; Cronbach's $\alpha = 0{\cdot}95$)[36] and REALD-99 (Cronbach's $\alpha = 0{\cdot}86$)[35] are efficient word recognition surveys used to assess dental health literacy. Gong *et al.* validated the Test of Functional Health Literacy in Dentistry (TOFHLiD; Cronbach's $\alpha = 0{\cdot}63$). This test evaluates understanding regarding follow-up instructions after fluoride varnish application, prescriptions, appointments, instructions on toothpaste use, and Medicaid rights and duties[34]. The Comprehensive Measure of Oral Health Knowledge (Cronbach's $\alpha = 0{\cdot}74$) is an open-ended survey which measures basic knowledge of oral health, management of dental caries, periodontal disease and oral cancer[32]. All the above questionnaires are based mainly on the ability to comprehend basic dental terminologies and to communicate with the oral health professional in order to seek appropriate treatment. It is crucial to determine the dental health literacy; however, this approach might prove ineffective in low-income adults who are generally less literate. To date, no study has assessed nutrition knowledge related to dental caries in underserved populations, who are the most affected by dental caries.

The current newly developed instrument is a comprehensive assessment of the knowledge of foods and dietary practices that may be related to dental caries in low-income women. This instrument may help identify gaps in nutrition knowledge related to oral health in this income group. It also may serve as a useful guide for dental health professionals to provide optimum nutritional counselling to their low-income women patients. In a US study by Hayes *et al.*, an improvement in sugar intake behaviours was documented in patients who had received dietary counselling from dental practitioners[15]. The strengths of the newly developed scale are that is it a brief, self-administered questionnaire that can be completed in 10 min. Therefore, it provides a quick assessment of the nutrition knowledge in low-income individuals. In addition, it is designed at a 6th-grade reading level so that it can be used to measure knowledge in a low-income group, who are generally less educated. The multiple-choice design of the new instrument minimizes the probability of guessing the correct response compared with a true/false design.

A limitation of the present study was that the sample included a small percentage of women (7·3 %) who were born in non-US countries, where English may not be the primary language of communication. However, the questionnaire was made available in both English and Spanish to cater to the major demographics in the local area. This instrument would be of limited use in individuals who speak languages other than English and Spanish. Future research should be directed towards measuring utility and effectiveness of the instrument in public health settings.

Conclusion

The present research developed a validated and reliable tool to assess dental health-related nutrition knowledge in low-income individuals. This instrument may serve as a practical tool for dietitians, dental practitioners and public health educators for identifying gaps in nutrition knowledge related to dental caries. This information can be used in dental public health education campaigns for increasing dental nutrition knowledge among low-income women.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1368980019002714

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