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Association of added sugar intake and caries-related experiences among individuals of Mexican origin

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Abstract

Objective: Determine the association between key dental outcomes and added sugar intake using a survey instrument to assess added sugars, which was specifically tailored to immigrant and US-born adults of Mexican origin.

Methods: Hispanic adults of Mexican origin (n = 326; 36.2 ± 12.1 years) completed a self-administered survey to gather acculturation, self-reported dental experiences and self-care practices (eg brushing, flossing, pain, bleeding gums), and socio-demographic information. The survey included a culturally tailored 22-item Added Sugar Intake Estimate (ASIE) that assessed added sugar intake from processed foods and sugar-sweetened beverages in a semiquantitative food frequency questionnaire format. Linear regression, 2-sample t test, and ANOVA were used to evaluate associations of demographic and dental outcomes with daily added sugar intake.

Results: Of the mean total daily added sugar intake (99.6 ± 94.6 g), 36.5 ± 44.4 g was derived from sugar-containing foods and snacks, and 63.1 ± 68.2 g from beverages. Participants who reported greater added sugar intake were more likely to have reported the presence of a toothache in the preceding 12 months, having been prescribed antibiotics for dental reasons, being less likely to floss daily, have reported eating or drinking within 1 hour before bed and have lower psychological acculturation (P < .05 for all). Results were comparable when assessing intake from sugar-containing foods/snacks and sugar-sweetened beverages.

Conclusions: This study confirmed the association between added sugar intake and self-reported dental outcomes among adults of Mexican origin and points to an urgent need to improve dietary behaviours in this population.

KEYWORDS
added sugars, dental caries, Mexican-American, oral health, self-care behaviours

1 | INTRODUCTION

Dental caries is largely a consequence of bacteria producing an acidic environment in the mouth, supported by high consumption of simple sugars.[1] Preventive efforts that may reduce the need for costly clinical intervention are unevenly distributed across the United States (US) population, resulting in significant oral health disparities.[2] Hispanics, the nation's largest minority group,[3] have one of the highest prevalence rates of untreated caries (36% vs 22% among non-Hispanic whites) and periodontitis (64% vs 41% among non-Hispanic whites) and one of the lowest utilization rates of dental care.[2,4]

The dietary quality of people of Mexican origin deteriorates with greater acculturation or longer residence in the US,[5,6] resulting in higher intake of processed foods with added sugars, and higher in saturated fats.[7,8] Recent Mexican immigrants' diets are lower in added sugars than those of more acculturated Hispanics of Mexican origin.[9] With higher acculturation, individuals increase intake of added sugars and processed foods, including ready-made foods and

reduce intake of fresh fruits and vegetables.[5-9] These changes have been associated with increases in body mass index, and higher risk for cardiovascular disease, insulin sensitivity and diabetes.[7,10] Although the relationship between sugar intake and oral health has been established,[1,11] there is scant information regarding how acculturative changes in diet and consumption of sugar-containing foods impact oral health among Hispanics of Mexican origin. Moreover, although surveillance data include dietary intake of Mexican-Americans, most dietary assessment instruments were developed for the general population and may overlook important sources of sugar consumed by individuals of Mexican origin.

Our study sought to explore the association between key dental outcomes and added sugar intake. Intake was assessed through a survey instrument tailored for adults of Mexican origin, measuring processed foods, snacks and beverages containing added sugars.

2 | METHODS

Data for this cross-sectional analysis were derived from the TalaSurvey Study;[12,13] its recruitment and study procedures were approved by the Indiana University Institutional Review Board (#1306011692).

2.1 | Participants and study procedure

Participants were all adults of Mexican origin, residing in urban neighbourhoods in central Indiana. Participants were recruited in 2013 through public announcements made in churches and community organizations, and via flyers and posters in businesses and agencies serving the Hispanic community. Potential participants were informed that the study was covered by a Certificate of Confidentiality by the US Federal Government, which would protect participants from compulsory legal demands to reveal participant information. This Certificate intended to minimize self-selection of participants with legal residence status.

All study procedures were offered in English or Spanish, by participant preference. Trained bilingual, bicultural research staff described the study to potential participants and allowed them to ask questions. Interested participants then signed an informed consent form prior to completing the self-administered survey, available in English and Spanish at a 3rd grade reading level. Bilingual staff were available to explain questions or answer options.

2.2 | Survey measures

2.2.1 | Added sugar intake estimate (ASIE)

Participants completed the semi-quantitative food frequency questionnaire format added sugar intake estimate (ASIE). Following a semi-quantitative food frequency format, each question of the ASIE first asks the frequency consumption of each specific item category (never, a few times per year, once a month, 2-3 times a month, once a week, twice a week, 3-4 times a week, almost every day and every day), and then asks for the portion size and the number of portions consumed each time, and whether respondent drank/ate the item within 1 hour of going to bed. To determine portion size, actual standard-portion plates and cups were shown. The 22-item culturally tailored ASIE was developed by adapting specific questions from the National Cancer Institute Diet History Questionnaire II (NCI-DHQII)[14] that focus on sugar-containing processed foods and beverages to include specific foods, snacks and beverages frequently consumed by individuals of Mexican origin, both in Mexico and in the US (desserts, candy, spreads, pastries, cookies, fruit/vegetable juices, fruit-flavoured drinks, other sugar-sweetened beverages and flavoured milk). Three bicultural project team members familiar with the diet of Mexican origin individuals independently reviewed the NCI DHQII to select relevant items that included foods commonly consumed by the target population; discrepancies were resolved by consulting with 2 additional experts. With the exception of fruit/vegetable juices, plain and evaporated unsweetened milk, and a few fruit-based dessert items, the ASIE did not include sources of naturally occurring sugars (eg vegetables, dairy products other than milk). In this way, the ASIE mainly focuses on *added* sugars. Estimated added sugar intake is reported as added sugar from foods/snacks, added sugar from sugar-sweetened beverages and the sum of both (total added sugar). See Appendix S1 for a description of ASIE development, sugar quantitation analyses and food item categories (Table S1).

2.2.2 | Psychological-behavioral acculturation scale (P-BAS)

This scale has been validated for individuals of Mexican origin living in the American Midwest[15] and incorporates distinct behavioural and psychological domains. The behavioural domain focuses on the acquisition of behaviours adaptive to a new environment (eg language use; TV/radio or music preferences; types of social events/clubs attended), while the psychological domain centres on norms, ideologies, beliefs and attitudes that resemble the mainstream culture. Both scores are reported as standardized values on a scale from 0 to 5. For behavioural acculturation, higher scores indicate greater acculturation. For psychological acculturation, values can be positive or negative (range: +5 to −5); a negative score indicates lower acculturation.

2.2.3 | Measures of dental experiences and self-care, and of socio-demographic information

Participants' age (in years), income (self-reported in 10 groups, from <US$10 000 to >US$90 000/y/household), marital status (single, married or in domestic partnership, separated/divorced, widowed), education (none, some elementary school, elementary school complete, some middle school, middle school complete, high school complete, university degree), medical (yes/no) and dental insurance coverage (yes/no) and US citizenship or permanent resident (yes/no) were self-reported, as were dental experiences and dental self-care practices (Table 1). These items were assembled from the CDC/NIDCR Data Resource Center collection of national surveys.[16]

The size of the town where participants were born (village, small town, large town, city, regional capital) was self-reported based on respondents' perceptions of their communities. We assessed dental fatalism with 3 questions partially derived from Finlayson et al[17,18] and adjusted per input from focus groups during formative research. Respondents were asked to estimate the likelihood of a negative dental outcome being under their control on a Likert-type scale (needing urgent dental care, losing teeth as one gets older, and inevitability of children having caries).

2.3 | Statistical analyses

Associations of socio-demographic and dental questionnaire items with daily added sugar intake were analysed using 2-sample t tests, ANOVAs or linear regression as appropriate separately for each variable. For the ANOVAs, post hoc pair-wise tests were performed when the overall test was significant. Multiple variable linear regression was used to evaluate all socio-demographic predictors of daily added sugar intake simultaneously in the same model. Education was entered as a count variable for the regression analysis. The evaluations of daily added sugar intake's relationship with the dental outcomes were restricted to bivariate analyses for association rather than multivariable predictive models because (i) current daily added sugar intake may not be "predictive" of the dental outcomes if the sugar intake has changed over time, and (ii) predictors of dental outcomes may not be adequate for providing a relevant base model for evaluating the additional effect of daily added sugar intake on the dental outcomes. The natural logarithm of daily added sugar intake was used for the analyses to achieve normality. Positive beta (regression) coefficients in the linear regression models indicate association with increased added sugar intake; negative coefficients indicate decreased added sugar intake. All analyses were undertaken in SAS 9.4 (SAS Institute Inc., Cary, NC). A 5% significance level was used for all tests.

3 | RESULTS

3.1 | Participant characteristics, dental health outcomes, and self-care practices

A total of 332 participants completed the survey. One was removed from the analysis due to extremely high reported added sugar intake (>1250 g/d), which was deemed implausible. Five additional participants were removed due to incomplete responses for 5 or more food categories. The final analyses included 326 participants.

Participants' mean age was 36.2 years (SD = 12.1 years; range: 18-69), and mean annual income was $30 577 (SD = $13 665; range: $10 000-$95 000; data not shown). Most participants (64%) were female. Most lived with a partner (62%), whereas 31% were single and 6% were separated, divorced or widowed. A minority of participants (20%) were US citizens or permanent residents. About a third of participants (32%) reported a level of education lower than middle school, 24% reported completing middle school, 32% reported completing

high school and 11% reported a college degree. Less than half of participants (46%) reported medical insurance; most (63%) had no dental insurance. Mean psychological acculturation score was −1.51 (SD = 1.36; range: −4.18 to +3.17), and mean behavioural acculturation score was 2.42 (SD = 0.94; range: 1-5), with both indicating low acculturation.

Participants' dental health outcomes and dental self-care practices are shown in Table 1. Over a third (39%) reported visiting the dentist at least once per year, with most (74%) seeking care at a dental office. Most (65%) reported currently needing dental treatment; most of those indicated the need for dental care soon (86%). Approximately, a third (35%) had experienced dental pain in the past 12 months or had sore or bleeding gums (37%) in the past 6 months, with 26% having been prescribed antibiotics in the past 12 months because of dental problems. Most reported they were likely to highly likely to brush their teeth twice daily and floss daily (86% and 60%, respectively). However, only 35% reported flossing at least 4 times per week and over a third (31%) reported no flossing. Most (73%) reported eating or drinking within 1 hour before bed.

3.2 | Differences by sociodemographic factors

Mean total daily added sugar intake was 99.6 g (SD = 94.6 g), of which 36.5 g (SD = 44.4 g) were derived from foods and snacks and 63.1 g (SD = 68.2 g) from beverages. In bivariate analyses (Table 2), total daily added sugar was greater for male than female participants (P = .0403). Lower psychological acculturation scores (r = −.14, P = .009) and higher behavioural acculturation scores (r = .13, P = .0195) were associated with higher daily added sugar intake. In the multivariable analysis (Table 3), sex (P = .045) and psychological acculturation scores (P = .012) were still significant; associations of higher added sugar intake with more education (P = .09) and higher dental fatalism scores (P = .08) approached statistical significance (P-values between .05 and .10).

Younger age was associated with higher daily added sugar intake from snacks and foods (r = −.18, P = .001). The multivariable analysis showed significance for age (P = .008) and for dental fatalism (P = .024), with higher dental fatalism scores associated with higher added sugar intake from snacks and foods, and lower psychological acculturation scores with higher added sugar intake approached statistical significance (P = .08).

Added sugar intake from beverages was greater for men than women (P = .002). Lower psychological acculturation scores (r = −.15, P = .007) and higher behavioural acculturation scores (r = .11, P = .046) were associated with higher added sugar intake from beverages. The multivariable analysis showed that sex (P = .001) and psychological acculturation scores (P = .012) were still significant, with older age (P = .07) and not having dental insurance (P = .10) approaching statistical significance for associations with higher added sugar intake from beverages. There were no differences in daily added sugar intake (total, from snacks/foods, or from beverages) by marital status, US residence status, or medical insurance status (Appendix S2).

TABLE 1 Description of self-reported oral health-related outcomes and self-care practices[a]

Outcome/Behaviour	N (%)
How often do you go to the dentist or dental hygienist? YES if answer = Every 6 mo/Once a year (Dental visit at least 1× per year)	
No	184 (61)
Yes	119 (39)
Have you ever sought care for tooth problems outside a private dental office? (Dental care at nondental location)	
No	222 (74)
Yes	78 (26)
Where have you sought care for tooth problems outside a private dental office? YES if answer = ER (Dental care at ER)	
No	313 (96)
Yes	13 (4)
Do you currently need dental treatment? (Currently need dental care)	
No	77 (25)
Yes	204 (65)
I don't know	33 (11)
If yes, how soon do you feel you need treatment? YES if answer = Immediately (Need dental care soon)	
No	26 (14)
Yes	158 (86)
How would you describe the condition of your teeth and gums? YES if answer = excellent/very good/good (Condition of teeth/gums excellent/very good/good)	
No	201 (63)
Yes	118 (37)
DURING THE PAST 12 MO, did you have pain in your teeth (a dull, aching pain across your face or cheek)? (Toothache in the last 12 mo)	
Yes	115 (35)
No	211 (65)
DURING THE PAST 6 MO, how often did you suffer from sore or bleeding gums? (Sore/bleeding gums in the last 6 mo)	
Yes	115 (37)
No	198 (63)
Have you been prescribed antibiotics or painkillers because of problems with your teeth in the past year? (Antibiotics in the last 12 mo)	
No	230 (74)
Yes	81 (26)
How many of your adult teeth have been removed SPECIFICALLY because of tooth decay or gum disease? YES if answer ≥1 tooth (Any teeth removed due to caries/gum disease)	
No	172 (53)
Yes	154 (47)
*DURING THE PAST 6 MO, how often were you self-conscious or embarrassed because of the way your mouth **looks**? (Embarrassed by the way mouth looks)*	
Often	28 (9)
Sometimes	102 (32)
Rarely	74 (23)

(Continues)

TABLE 1 (Continued)

Outcome/Behaviour	N (%)
Never	88 (27)
I don't know	29 (9)
DURING THE PAST 6 MO, how often were you self-conscious or embarrassed because of the way your mouth smells? (Embarrassed by the way mouth smells)	
Often	12 (4)
Sometimes	110 (34)
Rarely	85 (27)
Never	83 (26)
I don't know	30 (9)
DURING THE PAST 6 MO, how often did you feel that life in general was less satisfying because of problems with your mouth or your breath? (Life less satisfying due to mouth/breath)	
Very often	14 (4)
Occasionally	87 (27)
Hardly ever	66 (20)
Never	134 (41)
I don't know	22 (7)
DURING THE PAST 6 MO, how often did you avoid particular foods because of problems with your mouth? (Avoid foods because of mouth problems)	
Very often	14 (4)
Occasionally	91 (28)
Hardly ever	77 (24)
Never	129 (40)
I don't know	11 (3)
How likely are you to always brush your teeth 2 or more times a day? (How likely to brush 2× daily)	
Highly unlikely	16 (5)
Unlikely	10 (3)
Neither unlikely nor likely	19 (6)
Likely	35 (11)
Highly likely	239 (75)
How many times a day do you brush your teeth? (Actual times you brush daily)	
0-1	28 (9)
2	182 (58)
3+	103 (33)
How likely are you to floss your teeth at least once a day? (How likely to floss daily)	
Highly unlikely	53 (17)
Unlikely	25 (8)
Neither unlikely nor likely	44 (14)
Likely	50 (16)
Highly likely	139 (45)
In the last week, how many days did you use dental floss or any other device (like FlossPicks or Stim-U-Dent) to clean between your teeth? (Actual times you floss weekly)	
0	91 (31)

(Continues)

TABLE 1 (Continued)

Outcome/Behaviour	N (%)
1-3	97 (34)
4-6	49 (17)
7+	52 (18)
I often eat (anything) within 1 h of going to bed (Eat or drink within 1 h before bedtime)	
No	89 (27)
Yes	237 (73)
I often eat (food or snack) within 1 h of going to bed (Eat snack/foods within 1 h before bedtime)	
No	154 (47)
Yes	172 (53)
I often drink (beverage) within 1 h of going to bed (Drink within 1 h before bedtime)	
No	115 (35)
Yes	211 (65)

[a]Specific survey items are included with variable names noted in parenthesis. For dichotomized variables, answer options considered for "YES" are noted.

3.3 | Associations of added sugar intake with dental outcomes and self-care

In bivariate analyses (Table 2), total daily added sugar was greater for those who reported having a toothache in the preceding 12 months ($P = .0103$), or who had been prescribed antibiotics for dental reasons ($P = .0134$); those who stated they were less likely to floss daily (unlikely > likely $P = .0010$, unlikely > highly likely $P = .0056$, neutral > likely $P = .0196$); and those who reported eating or drinking within 1 hour before bed ($P < .001$). Participants who said "I don't know" when asked about avoiding foods because of mouth problems had higher daily added sugar intake ($P \leq .035$), while participants who "very often" avoided foods had lower intake than those responding hardly ever ($P = .017$) or never ($P = .016$).

Daily intake of added sugar from snacks and foods was greater for participants who reported having had a toothache in the past 12 months ($P = .0328$), or who had been prescribed antibiotics associated with dental pain ($P = .0364$), and those who reported eating or drinking within 1 hour before bed ($P \leq .002$). The number of times participants flossed per week was also significantly associated with added sugar intake from snacks and foods ($P = .0499$); however, the trends were unexpected—flossing 1-3 times per week was associated with higher added sugar intake than no flossing ($P = .0112$) or flossing 4-6 times per week ($P = .0392$), but no significant differences were found for daily flossing.

Daily intake of added sugar from beverages was greater for those reporting a toothache in the preceding 12 months ($P = .0049$), and for those prescribed antibiotics ($P = .0140$); participants who ate or drank within 1 hour before bedtime ($P \leq .002$); and participants who were less likely to floss daily (highly unlikely > likely $P = .0242$; unlikely > likely $P = .0009$; unlikely > highly likely $P = .0060$; neither unlikely nor likely > likely $P = .0321$).

There were no differences in daily added sugar intake (total, from snacks/foods, or from beverages) by other dental outcomes and self-care practices (Appendix S2).

4 | DISCUSSION

Our study sought to explore the association between dental outcomes and added sugar intake in a survey tailored to urban adults of Mexican origin. The main dental findings from the TalaSurvey parent study have been published elsewhere.[12,13] Overall, factors associated with higher added sugar intake were toothache in the preceding 12 months, having been prescribed antibiotics for dental reasons, less likely to floss daily, eating or drinking within 1 hour before bed and lower psychological acculturation.

Some findings pertaining to the ASIE survey are noteworthy, such as the links found between higher ASIE scores and both toothache and antibiotics prescribed for dental reasons in the preceding 12 months and the strong association between higher added sugar intake and eating/drinking within 1 hour of going to bed. Such associations pose concerns about dental outcomes; overall Americans consume added sugars above the recommended levels.[19] A particularly problematic aspect is the consistent, strong association found between eating/drinking anything within 1 hour of going to bed (a risk factor for dental problems[20,21]) and higher ASIE scores. The present results add to the scant empirical evidence.

Other factors associated with greater added sugar intake do not lend to straightforward interpretation (such as likelihood of flossing vs actual flossing). While self-presentation biases might explain such discrepancies,[22,23] direct observation would be necessary to determine the degree to which self-report reflects actual practices, or to clarify the direction of effects (such as how avoidance of foods due to oral problems was related to lower ASIE scores).

National surveillance data from 2013 to 2014 indicate mean daily total sugar intake among adults was 111 g,[24] with Hispanic adults consuming 114 g.[25] When looking at added sugars, intake among US adults was 84 g (335 kcal) for men and 60 g (239 kcal) for women, corresponding to ~13% of total energy intake.[8] Mexican-American men and women reported 12.9% and 12.6% of energy intake from added sugars, respectively.[8] Current study participants' reported daily intake from sugar-containing foods/snacks and beverages was 99.6 ± 94.6 g. Any additional sugar consumed through natural sources (eg vegetables) and processed foods (eg dressings and sauces) was not assessed. ASIE estimates are within the realm of national consumption levels, and they suggest added sugar consumption is high in this study population.

Similar to what has previously been reported,[26] the main contributors to added sugars were sugar-sweetened beverages, which provided roughly twice the amount of added sugars as sugar-containing foods and snacks. Added sugar amounts provided by either beverages or foods and snacks alone surpassed current recommendations to limit added sugar intake to 37.5 g/d for men and 25 g/d for women to reduce the risk for cardiometabolic diseases.[27] It has been

suggested that total sugar intake should be even lower (2%-3% of total energy intake) to prevent dental caries.[28] In the present study, having a toothache or use of antibiotics were associated with higher daily added sugar intake and greater intake from sugar-sweetened beverages. In a 4-year prospective study, frequency of sugar-sweetened beverages was associated with increased caries risk in a dose-dependent manner.[29] This finding emphasizes the need to reduce sugar-sweetened beverage consumption.[19,30]

Both cultural norms related to preventive care and the acculturation process contribute to the deterioration of oral health among Mexican immigrants.[12,22,31] Although increased acculturation has been associated with greater use of dental care services,[32] it has also been associated with poorer diet and increased consumption of sugar-containing foods.[5,33] However, earlier studies have only assessed acculturation using traditional unidimensional scales, usually considering the degree to which immigrants only adopt behaviours

TABLE 2 Estimated added sugar intake from sugar-sweetened foods/snacks and beverages stratified by socio-demographic characteristics, oral health-related outcomes and self-care practices

Stratifying variable	Total added sugar from foods/snacks/ beverages (g/d)[a]	P-value	Added sugar from food/snacks (g/d)[a]	P-value	Added sugar from beverages (g/d)[a]	P-value
Sex						
Female	58.8 (51.0, 67.7)	**.0403**	20.3 (17.4, 23.8)	.9739	30.9 (26.2, 36.3)	**.0022**
Male	74.9 (62.4, 89.8)		20.3 (16.5, 24.8)		46.9 (38.0, 57.7)	
Toothache (in the last 12 mo)						
Yes	78.4 (65.1, 94.5)	**.0103**	24.4 (19.8, 30.0)	**.0328**	46.4 (37.4, 57.5)	**.0049**
No	57.8 (50.3, 66.4)		18.4 (15.7, 21.4)		31.5 (26.8, 36.9)	
Antibiotics (in the last 12 mo)						
No	58.1 (50.9, 66.3)	**.0134**	18.3 (15.7, 21.2)	**.0364**	32.3 (27.6, 37.6)	**.0140**
Yes	80.5 (64.5, 100.5)		24.8 (19.4, 31.7)		47.0 (36.3, 60.8)	
Avoid foods because of mouth problems						
Very often	33.5 (19.4, 57.4)	**.0073**	10.2 (5.4, 18.9)	.1068	21.2 (11.1, 39.8)	**.0424**
Occasionally	55.6 (45.0, 68.5)		19.9 (15.7, 25.2)		29.2 (22.8, 37.3)	
Hardly ever	68.5 (54.5, 86.0)		20.2 (15.7, 26.1)		40.2 (30.8, 52.4)	
Never	67.4 (56.6, 80.4)		20.8 (17.0, 25.2)		38.1 (31.0, 46.7)	
I don't know	136.7 (75.1, 248.1)		35.7 (18.3, 68.8)		70.2 (34.9, 140.2)	
How likely to floss daily						
Highly unlikely	68.8 (52.9, 89.5)	**.0089**	19.2 (14.1, 26.0)	.4961	42.8 (31.4, 58.2)	**.0075**
Unlikely	108.8 (74.3, 159.2)		27.5 (17.7, 42.4)		65.3 (41.7, 101.9)	
Neither unlikely nor likely	79.2 (59.3, 105.6)		24.6 (17.6, 34.2)		42.7 (30.4, 59.9)	
Likely	49.4 (37.6, 64.8)		19.0 (13.8, 25.9)		25.6 (18.5, 35.3)	
Highly likely	60.4 (51.3, 71.1)		19.9 (16.5, 24.0)		32.9 (27.1, 39.8)	
Actual times you floss weekly						
0	63.9 (51.8, 78.7)	.8024	17.3 (13.7, 21.8)	**.0499**	40.6 (31.8, 51.9)	.3013
1-3	70.9 (57.9, 86.8)		26.2 (21.0, 32.7)		36.4 (28.7, 46.1)	
4-6	67.6 (50.8, 89.9)		17.5 (12.7, 24.0)		41.7 (29.8, 58.1)	
7+	60.4 (45.8, 79.7)		21.7 (15.9, 29.4)		28.3 (20.4, 39.2)	
Eat or drink within 1 h before bedtime						
No	41.9 (33.9, 51.6)	**.0001**	13.7 (10.8, 17.4)	**.0002**	23.0 (18.0, 29.5)	**.0001**
Yes	75.6 (66.6, 85.8)		23.5 (20.4, 27.1)		42.7 (36.8, 49.5)	
Eat snack/foods within 1 h before bedtime						
No	52.4 (44.6, 61.6)	**.0006**	16.5 (13.8, 19.8)	**.0021**	29.1 (24.1, 35.1)	**.0021**
Yes	77.3 (66.4, 90.0)		24.4 (20.6, 28.8)		43.7 (36.6, 52.1)	
Drink within 1 h before bedtime						
No	45.6 (37.9, 54.8)	**.0001**	13.5 (10.9, 16.6)	**.0001**	26.5 (21.3, 33.0)	**.0006**
Yes	77.6 (67.8, 88.8)		25.3 (21.8, 29.4)		42.7 (36.4, 50.0)	

Bold p-values indicate statistical significance.

[a]Expressed as Mean (95% CI); values were calculated using the log-transformed data and then transformed back to the original grams per day scale.

TABLE 3 Multiple regression models of added sugar intake (total, from and food/snack, and from beverages) from self-reported socio-demographic variables

Effect	ln (total added sugar)		ln (added sugar from food/Snacks)		ln (added sugar from beverages)	
	Beta (SE)	P-value*	Beta (SE)	P-value*	Beta (SE)	P-value*
Intercept	3.68 (0.80)	<.0001	3.14 (0.85)	.0002	2.60 (0.91)	.0048
Female	−0.25 (0.12)	**.0457**	0.02 (0.13)	.8966	−0.45 (0.14)	**.0017**
Marital status		.5778		.2702		.9541
Single	0.12 (0.40)	.7676	0.10 (0.42)	.8062	0.17 (0.46)	.7068
Married or domestic partnership	0.19 (0.38)	.6240	0.23 (0.40)	.5690	0.14 (0.44)	.7549
Separated/divorced	−0.20 (0.46)	.6634	−0.35 (0.49)	.4807	−0.01 (0.53)	.9904
Widowed	0		0		0	
Education	0.08 (0.05)	.0890	0.08 (0.05)	.1134	0.07 (0.05)	.2132
US Citizen/Permanent Resident	0.11 (0.15)	.4603	0.04 (0.16)	.8164	0.05 (0.18)	.7666
Size of community where born		.5856		.1021		.4377
Village	−0.51 (0.44)	.2470	−0.29 (0.47)	.5430	−0.53 (0.51)	.3013
Small town	−0.57 (0.37)	.1243	−0.66 (0.39)	.0943	−0.33 (0.42)	.4312
Large town	−0.61 (0.37)	.1008	−0.55 (0.39)	.1631	−0.43 (0.43)	.3180
City	−0.52 (0.36)	.1558	−0.81 (0.39)	.0375	−0.14 (0.42)	.7469
Regional capital	0		0		0	
Has dental insurance	−0.07 (0.18)	.6820	0.16 (0.19)	.4056	−0.34 (0.20)	.0971
Has medical insurance	0.07 (0.18)	.7003	−0.13 (0.19)	.4955	0.29 (0.20)	.1629
Age	0.00 (0.01)	.7812	−0.02 (0.01)	**.0085**	0.01 (0.01)	**.0734**
Psychological Acculturation	−0.11 (0.04)	**.0125**	−0.08 (0.05)	.0801	−0.12 (0.05)	**.0122**
Behavioural Acculturation	0.05 (0.08)	.5700	−0.03 (0.09)	.7775	0.07 (0.10)	.4636
Dental fatalism	0.10 (0.05)	.0826	0.13 (0.06)	**.0242**	0.09 (0.06)	.1745

Bold p-values indicate statistical significance.
*P-value from t test with df = 288.

(ie behavioural acculturation, such as language learned); such evaluations fail to factor in psychological acculturation, encompassing issues such as preferred lifestyle. This dimension would reflect either how the immigrant absorbs values of the mainstream culture, or whether a person would start assimilating from a higher position in the acculturation continuum.[34] In the present study, higher psychological acculturation was associated with lower daily added sugar intake and added sugar from sugar-sweetened beverages. Although this may seem contrary to reports of greater sugar-sweetened beverage consumption with greater acculturation,[35] it appears a reasonable interpretation that a higher psychological acculturation suggests a deeper assimilation process in which individuals may be adopting values related to preventive care. Separate analyses of the TalaSurvey data set have found that both behavioural acculturation and psychological acculturation were moderately associated with dental insurance coverage, and greater behavioural acculturation predicted more frequent dental care of all types.[12] Notably, more psychologically acculturated participants were more likely to seek preventive dental care; this is not a dominant behaviour in Mexican culture.[22,23]

This study is innovative in having incorporated interrelated variables, namely acculturation, added sugar intake and oral health. The study focused on a vulnerable population in the American Midwest: adults, predominantly female, mostly immigrant, with relatively low average income and education levels, and with low levels of acculturation, yet with considerable heterogeneity in reported dental services utilization, health status and clinical needs. Although these features limit generalizability somewhat, this is the first study assessing such interrelated variables in this underserved, understudied and vulnerable population. Further limitations include the inability to establish causation due to the cross-sectional nature of the study design, social desirability bias associated with self-reported data and selection bias resulting from sampling strategies designed to recruit from areas with a greater Hispanic population density.

The ASIE may have been affected by distortions in self-reported levels as well as wide variability in reported added sugar intake, as indicated by the wide standard deviations of total added sugar; alternatives such as 24-hour dietary recalls or duplicated plate measurements are the gold standard, but their use in research or clinical settings is limited by their high cost and considerable participant burden. The ASIE assesses the most important sources of added sugars in the target population, while responding to the need for affordable, reliable and culturally competent instruments to assess dietary intake of ethnic minority populations. One further limitation is that ASIE does not

exhaustively discern between added sugars and naturally occurring sugars. However, a majority of food items included in the ASIE have a predominant amount of added sugars relative to naturally occurring sugars. Although food frequency questionnaires are often used, the ASIE may have overestimated added sugar intake given that it largely focuses on sugar-containing food items,[36] especially considering that limited literacy and numeracy skills may impact some participants' estimation and report of usual intake. This limitation was minimized with interviewer-assisted survey completion and actual plates/cups to illustrate portions.

Although there is a need for future research to develop better instruments for more accurately assessing sugar intake in this population, the current ASIE could be used as a screening tool to identify individuals at high risk for dental caries due to high consumption of added sugar. Evaluation of the clinical utility of the ASIE for this purpose warrants further investigation. Nevertheless, our findings confirm the association between added sugar intake and dental outcomes, and underscore the need for efforts to reduce the high sugar intake in this population.

CONFLICTS OF INTEREST

Authors state they do not have conflicts of interest pertaining to this study.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

Table S1. Grouping of foods/drinks/snacks in ASIE questions posed about intake, amount, and frequency in the past year.

Item	Foods/Drinks/Snacks Included
1	Ice Cream, raspados, Frosties, sherbet, popsicle, strawberries with cream, bananas with cream, any fruit with cream, or with condensed milk (La Lechera milk), or fruit in syrup.
2	Puddings made with milk, for example puddings, flan, napolitanos, gelatinas de leche, arroz con leche, jericallas, kremel, mousse de chocolate, yogurt, etc.
3	Chocolates, chocolate de barra La Abuelita, Carlos V, Milky Way, Kisses, M&Ms, Hershey's, etc.
4	Non-chocolate candy, caramelos, paletas, glorias, morelianas, chiclosos, chewing gum (the latter just for chewing, not eating), etc.
5	Syrup, jelly, honey, molasses, piloncillo, leche condensada, panela, cajeta, dulce de leche, Nutella, crema chantilly, peanut butter.
6	Cake, doughnuts, Mexican sweet rolls (pan de dulce), pastelillos, capirotada, tostachos, corunda, bunuelo, tamales de dulce, bisquets, "Gansitos", "Twinkies" or similar pastries.
7	Cookies, pastries, galletas dulces, galletas Marías, Oreos, galletas danesas, galletas Emperador, Suavicremas, etc.
8	Pies, fruit puddings, pays, bread pudding, fruit tarts, sweet empanadas.
9	Sherbets, nieve, gelatina de agua.
10/11	Water, bottled wáter
12	Milk, not flavored or sweetened.
13	Reconstituted milk from powder, leche Nido, leche Nestle, Carnation milk, not flavored or sweetened.
14	Flavored or sweetened milk, such as Choco-Milk, NesQuik, etc.
15	Sodas, pop, refrescos, gaseosas.
16	Kool-Aid, Fresca, and other beverages reconstituted from powder or syrup added to water, such as horchata, jamaica, tamarindo.
17	Sport drinks (Gatorade, Powerade, etc.).
18	Energy drinks (Monster, Red Bull, etc.).
19	Fruit or vegetable juices, jugos Jumex, V8, coconut water – these are 100% fruit or vegetable juice
20	Fruit drinks, fruit based punch, Sunny Delight, Jugos Tampico, Boing.
21	Coffee (with added caloric sweetener, and excluding those using sugar free sweetener).
22	Herbal teas, regular teas (with added caloric sweetener, and excluding those using sugar free sweetener).

1   **Appendix S1.** ASIE development and cultural tailoring procedures, sugar quantitation analyses,

2   and instrument item categories.

3

4   *ASIE Survey Development.* The culturally-tailored Added Sugar Intake Estimate (ASIE) was

5   developed by adapting specific questions from the National Cancer Institute Diet History

6   Questionnaire II (NCI-DHQII)[14] that ask about intake of sugar-containing processed foods and

7   sugar-sweetened beverages to include specific foods, snacks, and beverages that are frequently

8   consumed by individuals of Mexican origin, both in Mexico and in the US. Three bicultural

9   project team members familiar with the diet of Mexican origin individuals independently

10   reviewed the NCI DHQII to select relevant items that included foods commonly consumed by

11   the target population; discrepancies were resolved by consulting with two additional experts.

12   Questionnaire items were modified or new items were added to more adequately reflect the

13   traditional dietary habits of individuals of Mexican origin. For example, the item originally

14   inquiring about intake of "doughnuts, sweet rolls, Danishes or pop-tarts" was expanded to

15   incorporate various pastry-type items common in the Mexican diet, including both traditional

16   bakery-made pastries (e.g. *pan dulce*) and commercially-processed pastries (e.g., *Gansitos*®).

17   The resulting 22-item semi-quantitative food frequency questionnaire, available in English and

18   Spanish, included the food categories identified as the sources of added sugars most commonly

19   consumed by the target population (desserts, candy, spreads, pastries, cookies, fruit/vegetable

20   juices, fruit-flavored drinks, other sugar-sweetened beverages, and milk/flavored milk; Table

21   S1). With the exception of fruit/vegetable juices, plain and evaporated unsweetened milk, and a

22   few fruit-based dessert items (e.g., strawberries with cream and sugar), most foods included in

23   the final ASIE contain a relatively small amount of naturally-occurring sugars relative to the

24   amount of sugars added in the manufacturing process (i.e., "added sugars"). Therefore, and

25   because the ASIE did not include other sources of naturally-occurring sugars (e.g., vegetables,

26   dairy products other than milk), the amount of sugar assessed with this instrument is being

27   considered as added sugars. This instrument does not assess total sugar intake. Estimated added

28   sugar intake is reported as added sugar from foods/snacks, added sugar from sugar-sweetened

29   beverages, and the sum of both (total added sugar from sugar-containing foods and beverages).

30   Following a semi-quantitative food frequency format, each question of the ASIE first asks the

31   frequency consumption of each specific item category (never, a few times per year, once a

32 month, 2-3 times a month, once a week, twice a week, 3-4 times a week, almost every day, and

33 every day), and then asks for the portion size and the number of portions consumed each time,

34 and whether respondent drank/ate the item within one hour of going to bed. In order to

35 determine portion size, actual plates and cups of different standard portions (e.g., 8, 12, 16 or 24

36 fl. oz. cups), were shown to each respondent.

37

38 *Formative Phase for ASIE Cultural Tailoring.* Following the initial questionnaire adaptation,

39 nine key informant interviews and three focus groups (n=24) were conducted to identify

40 individual foods, as well as typical portion sizes and frequency of intake, to be included as

41 examples in each of the ASIE questionnaire item categories. Specific food products, snacks, and

42 drinks were grouped by category, and categories were determined by focus group consensus.

43 During all phases of the formative research and adaptations we ensured appropriate literacy

44 levels at 3rd grade, and paid careful attention to aspects such understandability, terminology, and

45 clarity of language. All participants in this formative phase were adults of Mexican origin; they

46 did not take part in the main study data collection.

47

48 *Added Sugar Intake Estimate*. Sugar content of the foods or beverages included in each question

49 was abstracted from the USDA National Nutrient Database for Standard Reference 2016 (USDA;

50 http://www.ars.usda.gov/Services/docs.htm?docid=8964; Accessed June 10, 2016) for a

51 standardized portion of foods in each category (1/2 cup for solid foods, 8 fluid ounces for

52 beverages, and individual pieces for candy and similar items). The average sugar content for the

53 standard portion of foods within each category was then multiplied by the number of portions,

54 portion size, and frequency of intake (annualized) reported by participants. The resulting annual

55 consumption in grams of sugar was converted to a daily consumption by dividing it by 365.25.

1 **Appendix S2:** Non-significant differences in estimated added sugar intake from sugar-sweetened foods/snacks and beverages

2 stratified by sociodemographic characteristics, oral health-related outcomes, and self-care practices

Stratifying variable	Total Added Sugar from Foods/Snacks/Beverages (g/d)*	p-value	Added Sugar from Food/Snacks (g/d)*	p-value	Added Sugar from Beverages (g/d)*	p-value
Marital status						
Single	69.4 (56.8, 84.8)	0.5750	22.7 (18.2, 28.3)	0.1774	40.0 (31.6, 50.4)	0.7624
Married or domestic partnership	63.7 (55.2, 73.4)		20.2 (17.3, 23.6)		34.5 (29.2, 40.7)	
Separated / divorced	46.9 (26.5, 82.3)		12.4 (6.4, 23.3)		31.8 (16.3, 61.0)	
Widowed	54.7 (26.5, 111.9)		12.1 (5.1, 26.8)		37.6 (16.1, 85.9)	
Education						
None	45.8 (19.7, 104.9)	0.5932	15.5 (5.8, 38.7)	0.7546	29.8 (11.0, 77.8)	0.8768
Some elementary school	53.1 (36.5, 77.0)		19.0 (12.5, 28.7)		30.2 (19.5, 46.5)	
Elementary school complete	55.4 (40.0, 76.8)		16.1 (11.1, 23.2)		32.3 (22.0, 47.2)	
Some middle school	65.3 (45.0, 94.5)		21.3 (14.0, 32.0)		34.3 (22.2, 52.8)	
Middle school complete	62.4 (49.6, 78.4)		19.2 (14.9, 24.8)		36.4 (27.9, 47.5)	
High school complete	69.8 (57.2, 85.0)		22.7 (18.2, 28.3)		38.1 (30.2, 47.9)	
University degree	79.0 (56.3, 110.7)		22.1 (15.1, 32.1)		44.2 (29.8, 65.4)	
US citizen or permanent resident						
No	61.4 (54.1, 69.5)	0.0926	20.2 (17.6, 23.3)	0.9181	34.2 (29.6, 39.6)	0.1069
Yes	78.0 (60.4, 100.6)		20.6 (15.5, 27.2)		44.7 (33.4, 59.7)	
Has dental insurance						
Yes	65.9 (54.8, 79.1)	0.5987	20.6 (16.8, 25.3)	0.6164	35.0 (28.2, 43.3)	0.8400
No	61.9 (53.7, 71.3)		19.3 (16.5, 22.6)		35.9 (30.4, 42.4)	
Has medical insurance						
Yes	67.5 (57.2, 79.6)	0.2925	20.2 (16.8, 24.2)	0.7665	38.3 (31.6, 46.4)	0.2994
No	59.9 (51.4, 69.7)		19.4 (16.4, 23.0)		33.3 (27.9, 39.8)	
Dental visit at least 1x per year						
No	60.6 (52.4, 70.2)	0.3643	19.0 (16.1, 22.5)	0.4615	34.0 (28.7, 40.3)	0.4637
Yes	67.5 (56.3, 80.9)		21.0 (17.1, 25.8)		37.7 (30.5, 46.5)	
Dental care at non-dental location						
No	60.8 (53.1, 69.7)	0.1490	18.8 (16.1, 21.8)	0.0946	34.6 (29.6, 40.4)	0.1827
Yes	74.0 (58.8, 93.0)		24.2 (18.7, 31.1)		42.5 (32.7, 55.2)	
Dental care at ER						
No	64.9 (57.9, 72.8)	0.4818	20.1 (17.7, 22.9)	0.4855	36.7 (32.2, 41.9)	0.1999
Yes	52.8 (29.9, 92.7)		25.2 (13.5, 46.5)		23.7 (12.1, 45.6)	
Currently need dental care						
No	65.0 (51.5, 82.0)	0.4766	21.4 (16.5, 27.6)	0.2708	34.2 (26.1, 44.7)	0.6888
Yes	66.0 (57.2, 76.1)		20.7 (17.6, 24.2)		37.7 (31.9, 44.4)	
I don't know	52.1 (36.5, 74.3)		14.8 (9.9, 22.0)		32.0 (21.1, 48.2)	
Condition of teeth/gums excellent/very good/good						
No	66.3 (57.4, 76.5)	0.4531	20.6 (17.5, 24.1)	0.8726	37.3 (31.5, 44.0)	0.4223

Stratifying variable	Total Added Sugar from Foods/Snacks/Beverages (g/d)*	p-value	Added Sugar from Food/Snacks (g/d)*	p-value	Added Sugar from Beverages (g/d)*	p-value
Yes	60.6 (50.2, 73.1)		20.1 (16.3, 24.8)		33.3 (26.8, 41.4)	
Sore/bleeding gums (in the last 6 months)						
Yes	66.0 (54.6, 79.8)	0.8457	18.3 (14.8, 22.6)	0.1863	40.9 (32.9, 50.8)	0.2047
No	64.5 (55.8, 74.5)		21.9 (18.7, 25.7)		34.3 (29.0, 40.5)	
Any teeth removed due to caries/gum disease						
No	62.3 (53.4, 72.7)	0.5437	19.9 (16.7, 23.6)	0.7289	35.6 (29.7, 42.6)	0.8261
Yes	66.8 (56.7, 78.6)		20.8 (17.3, 24.9)		36.7 (30.3, 44.3)	
Embarrassed by the way mouth looks						
Often	60.1 (40.7, 88.5)	0.8186	16.0 (10.3, 24.6)	0.8067	39.0 (24.9, 60.9)	0.4149
Sometimes	64.2 (52.4, 78.6)		21.4 (17.1, 26.8)		34.3 (27.1, 43.3)	
Rarely	72.8 (57.4, 92.3)		19.4 (14.9, 25.3)		45.0 (34.2, 59.1)	
Never	60.4 (48.5, 75.1)		21.1 (16.5, 26.8)		31.6 (24.5, 40.7)	
I don't know	61.3 (41.9, 89.7)		20.9 (13.6, 31.7)		33.6 (21.6, 52.1)	
Embarrassed by the way mouth smells						
Often	88.8 (49.9, 157.5)	**0.0391**	27.5 (14.4, 51.7)	0.1105	56.8 (29, 110.2)	0.1230
Sometimes	63.9 (52.8, 77.3)		19.6 (15.8, 24.3)		35.8 (28.7, 44.7)	
Rarely	64.4 (51.9, 80.0)		21.1 (16.6, 26.9)		35.9 (27.9, 46.2)	
Never	76.1 (61.2, 94.7)		23.1 (18.1, 29.4)		42.7 (33.0, 55.0)	
I don't know	39.7 (27.4, 57.3)		12.4 (8.1, 18.8)		23.4 (15.2, 36.0)	
Life less satisfying due to mouth/breath						
Very often	40.6 (23.6, 69.4)	**0.0482**	13.4 (7.2, 24.5)	0.0757	27.1 (14.3, 50.7)	0.2309
Occasionally	55.3 (44.6, 68.5)		17.2 (13.5, 21.9)		30.6 (23.8, 39.4)	
Hardly ever	61.7 (48.2, 78.9)		18.2 (13.8, 24.0)		35.3 (26.4, 47.1)	
Never	73.6 (62.0, 87.5)		24.7 (20.4, 29.9)		40.3 (32.9, 49.3)	
I don't know	90.3 (59.0, 138)		23.6 (14.6, 37.8)		51.8 (31.5, 84.9)	
How likely to brush 2x daily						
Highly unlikely	50.4 (30.4, 83.4)	0.2607	12.4 (6.9, 21.8)	0.1387	29.8 (16.4, 53.4)	0.5606
Unlikely	108.2 (57.4, 203.1)		22.5 (11.0, 45.1)		59.4 (28.4, 123.1)	
Neither unlikely nor likely	84.5 (53.3, 133.7)		28.2 (16.9, 46.6)		44.8 (26.2, 76.3)	
Likely	67.9 (48.3, 95.2)		26.9 (18.5, 39.0)		34.7 (23.3, 51.5)	
Highly likely	61.9 (54.4, 70.5)		19.7 (17.0, 22.7)		35.1 (30.2, 40.8)	
Actual times you brush daily						
0-1	91.9 (62.9, 134.1)	0.0547	21.8 (14.2, 33.2)	0.2319	55.0 (35.4, 85.3)	0.0941
2	65.3 (56.3, 75.8)		21.5 (18.2, 25.4)		35.8 (30.1, 42.6)	
3+	55.0 (45.1, 67.0)		17.0 (13.6, 21.2)		31.7 (25.1, 39.9)	

3   * Expressed as Mean (SD) for all participants combined or Mean (95% CI) when stratified; values were calculated using the log-transformed data

4   and then transformed back to the original grams/day scale; bold p-values indicate statistical significance.