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The Association between Diabetes, Sugar Sweetened Beverages and Tooth Loss in Adults: Evidence from 18 States

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Abstract

Background—Sugar sweetened beverages (SSB) are dietary sources of sugar, factors in caries
development and tooth loss. Dietary sugar is also linked to diabetes mellitus (DM). There is
limited research with SSB and tooth loss in individuals with DM. The purpose of this study is to
investigate the association between SSB and tooth loss by the presence or absence of DM.

Methods—A cross-sectional design with data on adults (>18 years) from Behavior Risk Factor
Surveillance System, 2012 of 18 states was used (*n* =95,897; 40,413 with DM and 81,854 without
DM). Chi square, and logistic regression analyses by DM status were conducted.

Results—Overall, 12.3% had DM; 15.5% had   6 teeth removed; and 22.6% reporting drinking
1 SSB daily. In adjusted analyses, among adults with DM,   2 SSB daily were more likely to have
  6 teeth removed than adults reporting no SSB use (Adjusted odds ratio, AOR, = 2.35; 95% CI:
1.37, 4.01, *P*= 0.0018). Among adults without DM, those drinking >0 to <1 SSB/day were more
likely to have   6 teeth removed (AOR= 1.46; 95% CI: 1.21, 1.77, *P*< 0.0001).

Conclusion—Among adults with DM,   2 SSB/day were associated with   6 teeth removed.

Practical Implication—Dietary sugar is a concern for oral and systemic health; however, a strong, independent relationship between teeth removed and one, single source of dietary sugar is not adequate to explain the complexity of tooth loss and dietary messages should be broad when caries assessment is discussed.

Introduction

Tooth loss is a national and global public health concern. The U.S. Healthy People 2020 goal is to reduce tooth loss from a high of 76.4% in 1994–2004 to 68.8% in 2020.[1] There are many factors for tooth loss. These include predisposing biological factors such as sex, race/ethnicity, age, diabetes, and metabolic syndrome; disabling factors such as low education level, and low socioeconomic status; and behavioral factors such as infrequent brushing and flossing, tobacco use, drug/substance use, and/or sugar exposure.[2–6]

Even having a few missing teeth increases the risk of systemic diseases. Previous researchers have implicated missing teeth with cardiovascular disease, diabetes, all-cause mortality,[7] and metabolic syndrome.[8] Tooth loss has been associated with signs of sleep apnea,[9] swallowing difficulty in older adults,[10] and neurodegenerative symptoms.[11] Additionally, tooth loss can affect the quality of life. People with a greater number of missing teeth (as compared to people with fewer missing teeth) were more likely to report poor general health and depressive symptoms.[12–13]

In all ages (except for adults above age 80 years), the principal cause of tooth loss is dental caries,[14] a complex, multifactorial disease with ecological, biological, psychological, and sociological influences, among which is exposure to a diet high in refined carbohydrates/sugar. When considering tooth loss due to periodontal disease, a high carbohydrate diet has a profound impact on the gingival health and periodontal health by providing a food source for bacteria.

Researchers showed that a low carbohydrate diet, rich in Omega-3 fatty acids, fiber, and vitamins C and D reduced gingival/periodontal inflammation.[15] High glucose concentrations in-vitro increased cellular apoptosis[16] and inhibited periodontal ligament cell proliferation.[17] Therefore, although different biological pathways may be in effect, increased dietary sugar is a factor in oral health in terms of dental and periodontal health–problems considered to be worldwide pandemics. Additionally, overconsumption of dietary sugar has been associated with systemic diseases. Increased sugar intake is a risk factor for cardiovascular disease mortality,[18] hypertension, cardio-metabolic disease,[19] and increased body mass index.[20]

Sugar-sweetened beverages (SSB) and sports drinks are significant sources of dietary sugar, accounting for 34.4% of the sugar intake in the typical American diet.[21] Although SSB use had been steadily decreasing, recently SSB use has leveled or slightly increased with 23.9% of U.S. adults having had at least one SSB per day in 2011[22] and 26.3% having had at least one SSB per day in 2012.[23] For the average U.S. adult, the calories from added sugars should be 10% or less of total daily calories.[24] Researchers who were investigating the impact of SSB on oral health in recent studies have indicated positive associations between

SSB and dental caries,[25,26] whereas the research for SSB and tooth loss in adults is limited. SSB have been described as vehicles for delivering sugars to oral bacteria.[29]

In particular, people with DM are sensitive to increased dietary sugar in terms of their general health as well as in their oral health. Periodontitis and oral candidiasis are more common in people with DM.[27] A greater number of restored teeth, as the result of caries, and a greater number of extracted teeth were also observed in people with DM.[28]

The purpose of this study is to investigate if SSB (as a marker of a diet that includes fermentable sugars) is associated with increased tooth loss in adults with DM. Since the presence of DM is associated with tooth loss due to inflammatory and other biological pathways and drinking SSB (as a marker of a diet that includes fermentable sugars) is potentially associated with tooth loss through increased caries, we hypothesize a positive association of high SSB use with tooth loss in individuals with DM. The biological rationale is that SSB are significant sources of fermentable sugars; fermentable sugars are factors in oral bacterial growth; increased oral bacterial growth is related to 1) inflammation which may lead to periodontal disease and tooth loss; and 2) caries and tooth loss.

Methods

The data source for this research was the 2012 Behavior Risk Factor Surveillance System (BRFSS) data. BRFSS data were collected by state interviewers who contacted non-institutionalized U.S. adults, ages 18 years and above, through random-digit dialing of landline and cell phones.[30] The BRFSS researchers used a stratified sampling design and provided weights to account for no responses, inadequate coverage and differences in selection probability.[30] Optional questionnaire modules concerning SSB were presented to eighteen states. The states and their 2014 age-adjusted percentage of DM are: California (9.9%), Delaware (9.7%), Georgia (11%), Hawaii (8.9%), Iowa (8.3%), Kansas (9.5%), Maryland (9.2%), Minnesota (7.5%), Mississippi (11.9%), Montana (7.6%), Nebraska (8.4%), Nevada (8.8%), New Hampshire (7.9%), New Jersey(8.6%), New York (9.2%), Oklahoma (10.9%), South Dakota (8.2%), and Tennessee (11.7%).[31] There were 115,132 participants who were presented with the SSB questionnaire.

The researchers for this study extracted data from these 18 states. Inclusion criteria for this study were that the participants had complete data on SSB use, had an indicated DM status, and had data on the number of permanent teeth removed due to caries or periodontal disease. Complete data on these variables were available for 95,897 participants.

SSB consumption

There were two questions on the BRFSS survey which were used to determine SSB consumption of the participants. The two SSB questions were: "During the past 30 days, how often did you drink regular soda or pop that contains sugar? Do not include diet soda or diet pop;" and "During the past 30 days, how often did you drink sweetened fruit drinks, such as Kool-Aid, cranberry juice cocktail, and lemonade? Include fruit drinks you made at home and added sugar to."[30] A participant could respond to the BRFSS questions based upon his or her monthly, weekly, or daily use of SSB.

SSB categories were created based on previous research. For the χ^2 test, we used 4 mutually exclusive SSB intake categories: no SSB drinks/day; more than zero but less than 1 SSB drink/day; 1 to less than 2 SSB drinks/day; and 2 or more SSB drinks/day).

DM status was based on 2 BRFSS survey questions. The first question was "[Were you] ever told you had diabetes? If the participant answered "yes" and the participant was female, a follow-up question she was asked, "Was this only when you were pregnant?" The possible response were: "yes; yes but only during pregnancy; no; no but pre-diabetes or borderline diabetes; don't know/not sure; and refusal.[30] Researchers for this study coded responses which were "yes", or "pre-diabetes/borderline diabetes" as endorsing diabetes; and responses which were "no", or "during pregnancy" as no diabetes. Participants were not asked to distinguish among the types of DM by the BRFSS interviewers.

Outcome of Interest, Tooth Loss: Greater than or equal to 6 teeth removed

The number of permanent teeth removed was determined by using the responses to the BRFSS question: "How many of your permanent teeth have been removed because of tooth decay or gum disease? Include teeth lost to infection, but do not include teeth lost for other reasons, such as injury or orthodontics. (If wisdom teeth are removed because of tooth decay or gum disease, they should be included in the count for lost teeth)."[30] The possible responses to the questions on the BRFSS were: none; 1 to 5; 6 or more but not all; and all. Researchers studying tooth loss in other studies created dichotomized categories of missing teeth with various cut points. For example, some researchers have used cut points of 20 teeth;[32, 33] 25 teeth;[34] one tooth;[35] 6 teeth;[36–41] and edentulism.[42] In the BRFSS sample, 10% of participants had 6 or more teeth removed, and 5% had all teeth removed. For this current study, the data were dichotomized into the 2 groups: fewer than 6 teeth removed and 6 or more teeth removed. These two groups were combined for two reasons: 1) there is a basis to use 6 teeth as a cut point from the use of this cut point in previous research[36–41]; and 2) by collapsing the categories with only 10% and 5%, a larger sample size was created for more power.

Other variables associated with tooth loss

Other variables are known to be explanatory in the pathway to tooth loss and were included in the bivariate analyses. Significant variables from the bivariate analyses were included in the construction of the adjusted logistic regression model. These were: sex (female; male), race/ethnicity (Non-Hispanic white; Non-Hispanic black; Hispanic, other), age in years (18–29; 30–49; 50 and above), highest education level (less than high school; high school graduate; some college/technical school; college/technical school degree and above), family income level (an annual household income from all sources which is less than $15,000; $15,000 to less than $25,000; $25,000 to less than $35,000; $35,000 to less than $50,000; $50,000 and above), health (good to excellent; poor to fair), body mass index(BMI) (less than 25; 25 to less than 30; 30 and above), smoking status (current smoker; former smoker; never smoker), alcohol drinking (non-drinker; moderate; heavy), and physical activity (self-report of doing physical activity or exercise during the past 30 days other than their regular job: yes, no). Refusal/Don't know/missing were combined as missing categories for these additional variables were created.

We used χ^2 tests to examine the subgroup differences for teeth removed. Separate Logistic regression analyses were conducted on teeth removed to study the association between SSB and tooth loss by DM status after controlling for various factors that may be associated with tooth loss. The data were analyzed with survey procedures in SAS 9.3® (Cary, NC) software, which used data weights, for complex survey design and were provided in the BRFSS, 2012.

Results

The eligible sample consisted of 95,897 participants. The sample was predominantly Non-Hispanic white, age 50 years and above, in good to excellent health, physically active, and had a family income of $50,000 and above; and 14,043 (12.3%) reported having DM. There were 36, 143 (30.8%) who did not consume any SSB; 42,329 (46.6%) who consumed >0 to 1 SSB daily; 8,349 (9.3%) who consumed 1 to <2 SSB daily, and 9,076 who consumed 2 SSB daily (data not presented in tabular form).

The number and weighted percentages of study sample characteristics by tooth loss categories are described in Table 1. There were 30,926 (15.5%) who had 6 or more permanent teeth removed. A significant association between DM status and tooth loss was observed. A higher percentage of adults with DM reported tooth loss compared to adults without DM (34.0% versus 12.9%). Other details of variables in relationship to teeth removed are presented in Table 1.

Overall, of the participants who had 2 SSB daily, 16.9% had 6 or more teeth removed. Of the participants who had >1 to 2 SSB drinks/day, 19.3% had 6 or more teeth removed. (Table 2). In the overall sample, those with and without DM there were statistically significant relationships between SSB and permanent teeth removed ($P<.0001$).

Among those with DM, compared to adults without SSB consumption those who consumed 1 to <2 SSB daily (Odds Ratio -OR = 1.55, 95% CI = 1.04, 2.32; $P = 0.0302$) and those who consumed 2 SSB daily (OR = 2.06, 95% CI = 1.40, 3.03; p = 0.0002) were more likely to have 6 or more teeth removed. Among adults without DM, those who consumed 1 to <2 SSB daily were more likely to have 6 or more teeth removed (OR = 1.26, 95% CI = 1.06, 1.49; $P = 0.0093$) compared to those without any SSB use.

Among all adults with and without DM (results not presented in tabular form), multivariable logistic regression revealed that after adjusting for other explanatory variables, those with DM were more likely to have 6 or more permanent teeth removed (Adjusted Odds Ratio - AOR = 1.39; 95% CI = 1.20, 1.60; $P< .0001$) compared to those without DM. Similarly, those who consumed 2 SSB daily were more likely to have 6 or more teeth removed (AOR = 1.24; 95% CI = 1.02, 1.52; $P = 0.0352$).

Table 3 displays the results from the adjusted logistic regressions on 6 or more permanent teeth removed. The reference group for SSB categories was no SSB use. After adjusting for other explanatory variables, among adults with DM, those who consumed 2 SSB daily (AOR = 2.35, 95% CI = 1.38, 4.01; $P=.0017$) were more likely to have 6 or more teeth removed compared to adults without any SSB use. There was a marginally significant

association between 0 to <1 SSB/day and tooth loss (AOR of 1.46 (95% CI: 0.94, 2.27, 1.63; *P*=.0932). Among adults without DM, those who consumed 2 SSB daily (AOR = 2.35, 95% CI = 1.38, 4.01; *P* =.0017) were more likely to have 6 or more teeth removed compared to adults without any SSB use. The associations between other SSB groups and 6 or more teeth removed were not statistically significant.

Secondary Analyses

We also examined the relationship between SSB use and tooth loss with 4 categories. The tooth loss categories were: none of the teeth removed; 1 to less than 5; 6 or more (but not all); and all teeth removed. There were 44,957 (54.3 weighted %) who had no teeth removed, 30,024 (30.2%) with 1 to 5 teeth removed, 13,356 (10.6%) with more than six but not all teeth removed, and 7,560 (4.9%) with all teeth removed. The multivariable models consisted of multinomial logistic regressions with none of the teeth removed as the reference category for the dependent variable. For adults with DM, in a fully adjusted multinomial logistic regression model adults who consumed 2 SSB daily were more likely to have 6 teeth removed, but not all: AOR=2.20 [95% CI:1.19, 4.06) compared to those without any SSB use, All other relationships were not significant among adults with DM. None of the other SSB categories had statistically significant relationships with tooth loss among adults with DM.

Discussion

In this cross-sectional study, an overwhelming majority (84.5%) had no tooth loss defined as having 6 or more permanent removed and only 4.9% had all their teeth removed. In both bivariate and multivariable analyses, DM and 2 SSB daily were independently and significantly associated with tooth loss. However, when we analyzed the interaction between DM, SSB and tooth loss by conducting separate multivariable logistic regressions by DM status, we found that the relationship was not straight forward. For example, among adults with DM tooth loss was significantly associated only for those who consumed 2 SSB daily compared to no SSB consumption. For those without DM, adults who consumed 1 to <2 SSB daily were more likely to tooth loss compared to those without SSB use.

Similar studies

This current study supports results of other studies that individuals with DM are more likely to have permanent teeth removed as compared with individuals who do not have DM. Previous researchers have indicated a decrease in the mean number of permanent teeth removed due to caries or periodontal disease from 1971 to 2012 National Health Nutrition Examination Survey (NHANES) data (discounting SSB consumption).[4] In individuals with DM the mean number of permanent teeth removed decreased from 11.2 to 6.6 in that time period.[4] However, during the same time period, individuals who did not have DM had a more profound decrease in the number of permanent teeth removed (9.4 to 3.4 teeth removed).[4] Similar results were determined in an analysis limited to 2003–2004 NHANES data in which people with DM were more likely to have more missing teeth than people who did not have DM.[36]

Researchers conducted a study in which a younger sample (participants ages 18–39 years) was extracted from the same BRFSS data source, and in which there were no subgroup analyses on DM.[43] In that study, the AOR of having 6 teeth removed for participants who drank 2 SSB/day was 2.81 (95% CI:1.37, 5.76).[43] In our study, in subset analyses of individuals who had DM, individuals who consumed 2 SSB/day were more likely to have tooth loss compared to no SSB use. All other SSB categories failed to reach significance, suggesting that having 2 SSB/day can affect tooth loss in adults with DM. However, our secondary analyses did not indicate an association between 2 SSB/day and categories of tooth loss. These findings suggest that the relationship between SSB use and tooth loss categories is complex.

It is plausible that there are myriad factors that influence tooth loss and a single dietary factor, such as SSB, is inadequate to fully explain the association. Future research is needed to determine if there are factors mediating the relationship of SSB consumption and tooth loss, particularly in reference to the manner in which the SSB is consumed (al libitum, with or without a straw, with a meal, etc.), daily oral healthcare (brushing with a fluoride toothpaste, flossing, use of a fluoride rinse, etc.), consumption of other foods with a high sugar content, community water fluoridation and other factors.

The researchers of this study are the first, to the best of their knowledge, to have examined SSB and permanent teeth removed in adults specifically considering DM. SSB consumption and adverse dental health outcomes have been associated in children.[45–48] However, study results of tooth loss, SSB consumption in adults with and without DM have not been previously presented in peer-reviewed journals.

Liquid calories have been described as having less of a satisfying effect than solid food, thereby being a public health concern in terms of obesity as well as an oral health concern.[49] In a recent study comparing the benefits and risks of sugar substitutes in healthy, young adults aged 19–30 years, researchers assumed that if 100% of the sugar in SSB was replaced with 100% intense sweeteners, the benefit, beyond reduction in caries risk would be a BMI decrease of 1.7 kg/m2 in men and 1.3 kg/m2 in women without exceeding the acceptable daily intake of the sugar substitutes.[49] It is important to assess patient' SSB consumption as well as other dietary sources of sugar and provide anticipatory guidance.[29] Existing recommendations include only consuming SSB with meals, within a 15-minute time frame, with a straw, and with a limitation to 12 ounces or less per day for adults.[29]

Study strengths and limitations

This study does have strengths and limitations. The study has an epidemiological, cross-sectional design; therefore, temporality and cause/effects cannot be determined from the results. The study variables are also based on self-reports by the participants concerning their DM status, SSB consumption, and number of permanent teeth removed. The SSB consumption in this study can only be considered as a marker of a diet including fermentable carbohydrates and cannot be implicated alone without complete dietary data in the association with teeth removed.

There is a potential for misclassification bias if participants inaccurately responded to the questions; however, the BRFSS is a validated, nationally recognized survey which has been in place since 1984.[30] It is the largest continuously conducted survey in the world.[30] Questions are added to the BRFSS based upon prior cognitive and validity testing, history of prior use; and analytical plans.[30] Previous researchers have indicated that self-reports are reasonably accurate for screening examinations and certain chronic diseases and that the sensitivity of the BRFSS, 1993 was 73% for DM self-report.[50] In a study in which researchers were evaluating the sensitivity of diabetes self-report, the researchers indicated that self-report had a 85.2% sensitivity.[51] Nevertheless, there are people unaware of having DM. According to the CDC researchers, the overall prevalence of diabetes in the U.S. is 9.3% with an estimated 21 million individuals with diagnosed diabetes and 8.1 million individuals with undiagnosed diabetes.[31, 44] Approximately 1/3 (86 million) of Americans have prediabetes, a condition which increases the risk of type 2 DM.[52] Type 1 DM (failure of the pancreas to produce adequate insulin) is typically determined in youth. The incidence of type 1 diabetes in 2008–2009 was 18,436 in people younger than 20 years.[44] According to CDC researchers, of the people with diabetes, 95% having type 2 DM and 5% having type 1 diabetes.[52] By far, type 2 DM is the most prevalent type of DM, but it should be noted that the distinction was not made for this study. The SSB questionnaire module was presented in 18 states, among which 9 had a prevalence of DM above the national average of 9%, and 9 had a prevalence of DM below the national average of 9%; this provided a well-balanced sample. BRFSS is a large, highly regarded, national survey which has been conducted yearly by trained interviewers who use standardized, validated questions and the availability of SSB and tooth loss data in the same survey occurred with the BRFSS, 2012.

Conclusion and clinical implications

SSB consumption is a significant source of sugar in a typical American adult diet.[29]There is a need to assess and/or address SSB consumption and all sources of dietary fermentable carbohydrates and provide anticipatory guidance by dental professionals. Dental professionals are optimally positioned to counsel their patients not only on negative oral health consequences, but also associated negative systemic health consequences.[29] Education should be provided to patients regarding these recommendations in manners that are culturally relevant. The practical implication is that dietary messages should be broad when caries assessment is discussed.

Acknowledgments

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Table 1

Characteristics of the Study Sample by Missing Permanent Teeth Categories Adults Aged 18 years and Older from 18 States Behavioral Risk Factor Surveillance System, 2012

	0–5 Teeth Removed		6 or more Teeth Removed		
	N 74,981	Wt % 85.5	N 20,916	Wt % 15.5	*P*-value
All					
Diabetes Mellitus					<.0001
Yes	8,524	66.0	5,529	34.0	
No	66,457	87.1	15,397	12.9	
Sex					0.0179
Female	44,876	83.8	13,105	16.2	
Male	30,105	41.1	7,811	7.1	
Race/Ethnicity					<.0001
Non-Hispanic White	59,393	83.3	16,254	16.7	
Non-Hispanic Black	4,937	79.6	2,369	20.4	
Hispanic	3,278	90.6	515	9.4	
Other	6,777	87.4	1,600	12.6	
Missing	596	80.5	178	19.5	
Age in years					<.0001
18–49 years	29,288	94.9	1,815	5.1	
50 and above	45,693	72.2	19,101	27.8	
Highest education					<.0001
Less than high school	3,697	70.6	3,854	29.4	
High school	19,242	80.7	8,464	19.3	
Some College/Technical	21,101	86.7	5,444	13.3	
College	30,841	93.3	3,117	6.7	
Missing	100	77.6	37		
Family income					<.0001
Less than $15,000	5,211	74.2	4,125	25.8	
$15,000 to less than $25,000	9,327	75.4	5,193	24.6	
$25,000 to less than $35,000	7,068	79.6	2,668	20.4	
$35,000 to less than $50,000	10,144	85.1	2,497	14.9	

	0–5 Teeth Removed		6 or more Teeth Removed		P-value
All	**N 74,981**	**Wt % 85.5**	**N 20,916**	**Wt % 15.5**	
$50,000 and above	34,452	92.4	3,433	7.6	
Missing	8,779	82.1	3,000	17.9	
Smoking Status					<.0001
Current smoker	9,801	72.6	5,220	27.4	
Past smoker	20,764	77	8,297	23	
Never smoker	44,113	91.2	7,306	8.8	
Missing	303	86.8	93	13.2	
Alcohol Use					<.0001
Non-drinker	32,147	79.3	13,942	20.7	
Moderate	36,263	89.3	5,622	10.7	
Heavy	5,455	88.2	1,057	11.8	
Missing	1,116	88.9	295	11.1	
Physical Activity					<.0001
Yes	59,970	87.6	12,547	12.4	
No	14,903	73.2	8,333	26.8	
Missing	108	87	36	13	
Health Status					<.0001
Excellent/Very Good	42,866	92.1	5,977	7.9	
Good	22,178	82.8	7,101	17.2	
Fair/Poor	9805	65.2	7770	34.8	
Missing	132	80.7	68	19.3	
Body Mass Index					<.0001
Underwt/Normal	26,306	87.4	6,267	12.6	
Overweight	26,153	84.0	7,181	16.0	
Obese	19206	80.9	6782	19.1	
Missing	3,316	88.4	686	11.6	
No SSB	27,681	81.9	8,462	18.9	
SSB					<.0001
No SSB	27,681	81.9	8,462	18.1	
Less than 1 daily	34,495	87.4	7,834	12.6	

	0–5 Teeth Removed		6 or more Teeth Removed		
All	**N 74,981**	**Wt % 85.5**	**N 20,916**	**Wt % 15.5**	**P-value**
More than 1 to less than 2 daily	6,078	80.7	2,271	19.3	
2 or more daily	6,727	83.1	2,349	16.9	

Note: Based on 95,897 adults ages 18 years and above with no missing information on missing teeth, sugar sweetened beverage consumption per day, and diabetes status.

Abbreviations: SSB=sugar sweetened beverage; wt% = weighted percent.

P-values are based on chi-square tests between permanent missing teeth categories and subject characteristics.

Table 2

Number and Weighted Percentages of Missing Permanent Teeth Categories By Sugar Sweetened Beverage Categories and Diabetes Mellitus Status Adults Aged 18 years and Older from 18 States Behavioral Risk Factor Surveillance System, 2012

	0–5 Missing Teeth		6 or More Missing Teeth		
	N	Wt %	N	Wt %	p-value
All	**74,981**	**85.5**	**20,916**	**15.5**	
Sugar sweetened beverages					<.0001
No SSB	27,681	81.9	8,462	18.1	
Less than 1 daily	34,495	87.4	7,834	12.6	
More than 1 to < 2 daily	6,078	80.7	2,271	19.3	
2 or more daily	6,727	83.1	2,349	16.9	
Adults WITH Diabetes Mellitus (N = 14,043)					
All	**8,524**	**66.0**	**5,519**	**34.0**	
Sugar sweetened beverages					<.0001
No SSB	4,801	67.0	2,982	33.0	
Less than 1 daily	2,893	69.7	1,769	30.3	
More than 1 to < 2 daily	436	56.8	396	43.2	
2 or more daily	394	49.8	372	50.2	
Adults WITHOUT Diabetes Mellitus (N = 81,854)					
All	**66,457**	**87.1**	**15,397**	**12.9**	
Sugar sweetened beverages					<.0001
No SSB	22,880	85.8	5,480	14.2	
Less than 1 daily	31,602	89.2	6,065	10.8	
More than 1 to < 2 daily	5,642	82.8	1,875	17.2	
2 or more daily	6,333	85.6	1,977	14.4	

Note: Based on 95,897 adults with (N = 14,043) and without diabetes (N = 81,854) aged 18 years and older with no missing information on missing teeth, sugar sweetened beverage per day and diabetes status.

SSB=sugar sweetened beverage; wt% = weighted percent.

P-values are based on chi-square tests between permanent missing teeth categories and sugar sweetened beverage categories.

Table 3

Adjusted Odds Ratios (AOR) and 95% Confidence Intervals (CI) from Logistic Regressions on 6 or more Missing Permanent Teeth By Diabetes Mellitus Status Adults Aged 18 years and Older from 18 States Behavioral Risk Factor Surveillance System, 2012

	Diabetes Mellitus				No Diabetes Mellitus			
	AOR	95% CI	P-value	Sig	AOR	95% CI	P-value	Sig
Sugar sweetened beverages								
No SSB								
Less than 1 daily	0.96	[0.77, 1.21]	0.7523		1.01	[0.87, 1.16]	0.9338	
More than 1 to <2 daily	1.46	[0.94, 2.27]	0.0932		1.46	[1.21, 1.77]	0.0000	***
2 or more daily	2.35	[1.38, 4.01]	0.0018	**	1.12	[0.90, 1.38]	0.3017	
Sex								
Female	1.16	[0.93, 1.46]	0.1916		0.82	[0.72, 0.92]	0.0012	**
Male								
Race/Ethnicity								
Non-Hispanic White								
Non-Hispanic Black	1.11	[0.79, 1.54]	0.5519		1.22	[1.03, 1.43]	0.0190	*
Hispanic	0.41	[0.27, 0.62]	0.0000	***	0.39	[0.29, 0.51]	0.0000	***
Other	1.36	[0.82, 2.26]	0.2299		0.91	[0.63, 1.31]	0.5973	
Missing	1.35	[0.58, 3.16]	0.4917		1.21	[0.72, 2.03]	0.4676	
Age in years								
18–49 years								
50 and above	4.50	[3.11, 6.52]	0.0000	***	7.17	[6.05, 8.49]	0.0000	***
Highest education								
LT High School	2.75	[1.89, 4.02]	0.0000	***	3.48	[2.73, 4.43]	0.0000	***
High school	1.71	[1.23, 2.37]	0.0013	**	2.04	[1.67, 2.50]	0.0000	***
Some College	1.36	[0.95, 1.95]	0.0885		1.61	[1.33, 1.96]	0.0000	***
College								
Family income								
Less than $15K	1.66	[1.12, 2.45]	0.0108	*	2.42	[1.93, 3.04]	0.0000	***
$15k – < $25k	1.55	[1.12, 2.16]	0.0088	**	2.36	[1.96, 2.85]	0.0000	***
$25k – < $35k	1.13	[0.77, 1.66]	0.5213		2.01	[1.57, 2.58]	0.0000	***

	Diabetes Mellitus				No Diabetes Mellitus			
	AOR	95% CI	P-value	Sig	AOR	95% CI	P-value	Sig
$35k – < $50k	1.32	[0.93, 1.89]	0.1213		1.48	[1.23, 1.78]	0.0000	***
$50k and above								
Missing	1.53	[1.01, 2.33]	0.0439	*	1.78	[1.47, 2.15]	0.0000	***
Smoking Status								
Current smoker	3.54	[2.56, 4.90]	0.0000	***	3.56	[3.03, 4.19]	0.0000	***
Past smoker	1.89	[1.49, 2.40]	0.0000	***	2.34	[2.05, 2.67]	0.0000	***
Never smoker								
Missing	1.22	[0.52, 2.85]	0.6467		1.29	[0.70, 2.36]	0.4172	
Alcohol Use								
Non-drinker								
Moderate	0.70	[0.55, 0.89]	0.0031	**	0.70	[0.61, 0.81]	0.0000	***
Heavy	0.46	[0.25, 0.85]	0.0131	*	0.61	[0.48, 0.77]	0.0000	***
Missing	0.34	[0.17, 0.68]	0.0024	**	0.55	[0.41, 0.76]	0.0002	***
Physical Activity								
Yes								
No	1.38	[1.11, 1.72]	0.0040	**	1.23	[1.06, 1.43]	0.0057	**
Missing	2.28	[0.57, 9.22]	0.2457		0.70	[0.24, 2.01]	0.5062	
Health Status								
Excellent/Very Good								
Good	1.71	[1.30, 2.25]	0.0001	***	1.47	[1.28, 1.69]	0.0000	***
Fair/Poor	2.30	[1.71, 3.10]	0.0000	***	2.49	[2.12, 2.91]	0.0000	***
Missing	1.37	[0.41, 4.53]	0.6085		1.61	[0.86, 3.02]	0.1339	
Body Mass Index								
Underweight/Normal								
Overweight	1.17	[0.82, 1.67]	0.3956		1.14	[0.99, 1.32]	0.0684	
Obese	1.01	[0.72, 1.40]	0.9660		1.14	[0.97, 1.34]	0.1122	
Missing	1.05	[0.60, 1.86]	0.8581		0.68	[0.52, 0.87]	0.0029	**

Note: Based on 95,897 adults with (N = 14,043) and without diabetes (N = 81,854) aged 18 years and older with no missing information on missing teeth, sugar sweetened beverage per day and diabetes status.

Abbreviations: k in income represents 1000 dollars;

P-values are from logistic regressions on 6 or more missing permanent teeth based on chi-square tests between permanent missing teeth categories and subject characteristics.