Consumption of Sugar-Sweetened Beverages Among Adults With Type 2 Diabetes

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OBJECTIVE—To examine patterns of sugar-sweetened beverage (SSB) consumption among U.S. adults with type 2 diabetes in 2003–2006.

RESEARCH DESIGN AND METHODS—We analyzed 24-h dietary recall data from the National Health and Nutrition Examination Survey 2003–2006 to estimate SSB consumption levels among 1,090 adults (aged ≥20 years) with type 2 diabetes overall and by diagnosis and control status of their diabetes.

RESULTS—In 2003–2006, 45% of adults with diabetes consumed SSBs on a given day, obtaining an average of 202 calories and 47 g of sugar. Undiagnosed adults with diabetes were significantly more likely to consume SSBs than diagnosed adults (60 vs. 38% diagnosed/uncontrolled [$P < 0.001$] and 43% diagnosed/controlled [$P = 0.001$]) and were less likely to consume diet beverages (18 vs. 50% diagnosed/uncontrolled [$P < 0.001$] and 40% diagnosed/controlled [$P < 0.001$]). Men consumed significantly more SSBs than women ($P = 0.027$), younger adults (aged 20–44) more than older adults (45–64 and ≥65; $P < 0.001$), non–Hispanic black more than whites ($P = 0.010$); and low-income individuals (quartile 1) more than higher-income individuals (quartile 3, $P = 0.040$; quartile 4, $P = 0.013$). For most demographic and body weight categories, adults who were undiagnosed consumed more sugar from SSBs than adults who were diagnosed.

CONCLUSIONS—SSB consumption is high among adults with diabetes, particularly among those who are undiagnosed.

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Consumption of sugar-sweetened beverages (SSBs) has been linked to higher incidence of type 2 diabetes (1,2), which affects 10% of adults or 23.5 million Americans (3). The economic burden of diabetes is estimated to be $174 billion annually in direct and indirect costs (4). Of particular concern are minority and low socioeconomic status individuals, who are disproportionately affected by diabetes (5). The American Cancer Society, the American Diabetes Association, and the American Heart Association recommend that individuals with diabetes limit their intake of beverages with added sugar (6). The American Heart Association recommends that women consume no more than 25 g (~100 kcal) and men no more than 37.5 g (~150 kcal) per day of added sugar (7).

Although an extensive body of research has examined trends and patterns of SSB consumption and shows that consumption increased considerably for children (8) and adults (9) during the period 1988–1994 to 1999–2004—from 242 to 271 kcal/day among children and from 157 to 203 kcal/day among adults—no known studies have focused on individuals with diabetes. Replacing SSBs with noncaloric beverages can offer a relatively simple, low-cost option to improve glycemic control and help individuals with diabetes to achieve or maintain a healthy weight (10). Identifying variations in SSB consumption by subpopulation groups is also useful for the development of targeted policies or nutrition programs, or both.

The purpose of this study was to describe national patterns in the percentage of SSB drinkers and the consumption levels among U.S. adults with diabetes. In addition to overall consumption, we also investigated differences by whether their diabetes status was diagnosed and well controlled and by demographic characteristics and body weight category.

RESEARCH DESIGN AND METHODS

Data

The analytic sample consisted of adults aged ≥20 years with diabetes and with completed 24-h dietary recalls from the nationally representative National Health and Nutrition Examination Surveys (NHANES) 2003–2006. These years of data were selected because information on the grams of sugar contained in each beverage item was only available in NHANES 2003–2006. The NHANES is a population-based survey designed to collect information on the health and nutrition of the U.S. population. Participants were selected based on a multistage, clustered, probability sampling strategy. A complete description of data-collection procedures and analytic guidelines are available elsewhere (www.cdc.gov/nchs/nhanes.htm).

Study participants were considered to have diabetes if they met one or more of the following conditions: their fasting plasma glucose level was ≥126 mg/dL, they reported being told by a physician that they had diabetes, or they reported taking glucose-lowering medications. Survey respondents were excluded if they were pregnant at the time of data collection or if their dietary recall was incomplete or unreliable, as determined by the NHANES staff. Because of the small sample size of the "other race/ethnicity" category, we only included non–Hispanic

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white, non–Hispanic black (hereafter referred to as "whites" and "blacks"), and Mexican Americans in the analyses.

Measures

Diabetes categories. We classified NHANES adults with diabetes into three groups: those who were undiagnosed (hereafter referred to as "undiagnosed"), those who were diagnosed as having diabetes but who had uncontrolled diabetes (hereafter referred to as "diagnosed and uncontrolled" or "diagnosed/uncontrolled"), and individuals with diabetes who were diagnosed as having diabetes and who had controlled diabetes (hereafter referred to as "diagnosed and controlled" or "diagnosed/controlled"). Study participants were considered to be undiagnosed if they had a fasting plasma glucose level of ≥126 mg/dL and responded negatively to the question "Have you ever been told by a doctor that you have diabetes?" Study participants were considered to be uncontrolled and diagnosed if their glycated hemoglobin reading was ≥7.0% and they responded positively to the question "Have you ever been told by a doctor that you have diabetes?" Study participants were considered to be controlled and diagnosed if their glycated hemoglobin reading was <7.0% and they responded positively to the question "Have you ever been told by a doctor that you have diabetes?"

Beverages. Survey respondents reported all food and beverages consumed in a prior 24-h period (midnight to midnight) and reported type and quantity of each food and beverage consumption occasion. After the dietary interview, all reported food and beverage items were systemically coded using the U.S. Department of Agriculture Food and Nutrient Database. Caloric content and other nutrients derived from each consumed food or beverage item were calculated based on the quantity of food and beverages reported and the corresponding nutrient contents by the National Center for Health Statistics (NCHS). We identified two mutually exclusive beverage categories in the NHANES 2003–2006 (from 245 beverage items) including *1*) SSB (soda, sport drinks, fruit drinks and punches, low-calorie drinks, sweetened tea, and other sweetened beverages) and 2) diet beverages (diet sodas and sugar-free carbonated soda water). We did not include milk, coffee/tea, or alcoholic beverages in this analysis because guidelines for diabetes do not explicitly suggest reductions in those beverage categories.

Body weight status. Body weight and height were measured using standard procedures in a mobile examination center. Healthy weight was defined as a BMI from 18.5 to 24.9 kg/m^2, and overweight/obese was defined as a BMI ≥25 kg/m^2 (11).

Socioeconomic status. The poverty/income ratio (PIR)—the ratio of household income to a family's appropriate poverty threshold—was based on self-reported household income. We divided the poverty/income ratio into quartiles where quartile 1 represented lowest income and quartile 4 represented highest income. Education was categorized into two mutually exclusive categories: less than high school (or GED) and high school or more.

Analysis. Sampling weights were used to provide estimates that are representative of the U.S. population. Individuals with diagnosed diabetes from the entire interviewed sample were combined with individuals with undiagnosed diabetes from the plasma glucose subsample. Appropriate sampling weights were used such that the sum of the sample weights from the two groups added to the total U.S. population. All statistical procedures were conducted by using SAS 9.1 (SAS Institute, Inc., Cary, NC) and SUDAAN 9.0.1 (RTI, Research Triangle Park, NC) software to account for the complex sampling structure. Multivariate regressions were used to adjust for population composition during the survey period, including race/ethnicity, sex, income, age, marital status, employment status, and education. Using the regression model, we predicted the multivariate-adjusted marginals for each diabetes subcategory. We then compared these predicted means

Table 1—*Characteristics of U.S. adults (aged ≥20 years) with diabetes by diagnosis and control, NHANES, 2003–2006 (N = 1,090)*

Variable	All diabetes *N*	Undiagnosed % (SE)	Uncontrolled and diagnosed % (SE)	Controlled and diagnosed % (SE)
Total	1,090	27 (2.4)	33 (1.8)*	40 (2.4)*
Sex				
Male	548	33 (3.6)	32 (1.9)	35 (3.3)
Female	542	21 (3.0)	34 (3.0)*	45 (2.7)*
Race/ethnicity				
Non–Hispanic white	463	30 (3.3)	27 (2.5)	42 (3.2)*
Non–Hispanic black	300	19 (3.0)	49 (3.7)*	32 (2.7)*
Mexican American	284	32 (5.9)	41 (3.2)*	26 (4.4)
Age (years)				
20–44	139	30 (5.8)	35 (4.8)	35 (4.6)
45–64	431	23 (3.6)	40 (3.2)*	36 (3.6)*
≥65	520	30 (3.2)	25 (2.6)	45 (2.8)*
Education				
Less than high school	434	24 (3.5)	43 (3.6)*	33 (2.9)*
High school or higher	654	28 (2.9)	29 (2.2)	42 (3.0)*
Employment status				
Unemployed	386	19 (2.9)	34 (2.9)*	46 (3.3)*
Employed	154	38 (5.6)	32 (4.0)	30 (5.3)
Income				
Quartile 1 (lowest)	309	19 (2.9)	40 (3.4)*	41 (3.5)*
Quartile 2	300	32 (5.0)	27 (3.2)	41 (4.3)
Quartile 3	235	32 (5.0)	32 (3.6)	36 (3.4)
Quartile 4 (highest)	175	25 (5.3)	35 (4.5)	41 (5.3)*
Body weight status				
Healthy weight (BMI <25)†	165	26 (5.4)	41 (5.0)*	33 (4.2)
Obese/overweight (BMI ≥25)†	925	27 (2.3)	32 (1.9)	41 (2.5)*

Numbers are weighted to adjust for unequal probability of sampling. *$P < 0.05$ indicates the difference from the reference group (undiagnosed). †Healthy weight was defined as a BMI from 18.5 to 24.9 kg/m^2; overweight/obese, BMI ≥25 kg/m^2.

using *t* tests at a significance level of 0.05. All tables predicted means based on the adjusted multivariate models.

RESULTS—Table 1 reports the characteristics of the study sample. Overall, 50% of individuals with diabetes were women, 72% were white, 82% were aged ≥45 years, 75% had at least a high school education, 40% were employed, and 86% were overweight or obese. There were significant differences between patients with diabetes who were undiagnosed versus diagnosed and controlled or diagnosed and uncontrolled with respect to sex, race/ethnicity, age, education, employment status, income, and body weight status. Table 2 reports the percentage of adults with diabetes consuming different beverages, per capita caloric consumption from SSBs, and calories and grams of sugar consumed among SSB drinkers on the surveyed day. In 2003–2006, 45% of individuals with diabetes consumed SSBs and 38% consumed diet beverages (Table 2).

Undiagnosed adults with diabetes were significantly more likely to consume SSBs than diagnosed adults (60 vs. 38% diagnosed/uncontrolled [$P < 0.001$] and 43% diagnosed/controlled [$P = 0.001$]) and were less likely to consume diet beverages (18 vs. 50% diagnosed/uncontrolled [$P < 0.001$] and 40% diagnosed/controlled [$P < 0.001$]). Per capita consumption of SSBs was significantly higher among undiagnosed adults than diagnosed adults (128 vs. 65 kcal/day diagnosed/uncontrolled [$P = 0.004$] and 78 kcal/day diagnosed/controlled [$P = 0.036$]). We observed no significant differences between the three subgroups of diabetes for the daily caloric contribution from SSBs among drinkers or for the daily grams of sugar from SSBs.

Table 3 presents average daily grams of sugar from SSBs by demographic groups and body weight category. Daily average grams of sugar intake was significantly higher among men than in women ($P = 0.027$), in young adults (aged 20–44) than in older adults (aged 45–64; $P < 0.001$) and the elderly (aged ≥65; $P < 0.001$), in blacks compared with whites ($P = 0.010$), and in low-income individuals (quartile 1) than in higher-income individuals (quartile 3, $P = 0.040$; quartile 4, $P = 0.013$). We observed no significant differences in average daily grams of sugar by education or body weight category.

Several notable patterns emerged among the three subgroups of diabetes. Compared with their undiagnosed counterparts, men ($P = 0.003$), younger adults (aged 20–44; $P = 0.049$), the elderly (aged ≥65; $P = 0.002$), whites ($P = 0.007$), individuals with a high school degree or higher education ($P = 0.002$), quartile 2 of income ($P = 0.005$), and healthy weight individuals ($P = 0.011$) who were diagnosed but uncontrolled were significantly less likely to consume sugar from SSBs. Similarly, the elderly (aged ≥65; $P = 0.004$), individuals with a high school degree or higher education ($P = 0.037$), and quartile 2 of income ($P = 0.005$) who were controlled and diagnosed were significantly less likely to consume sugar from SSB than their counterparts who were undiagnosed. We observed no differences by demographic characteristics or body weight category among adults who were diagnosed as having diabetes.

Table 2—***Percentage (%) of U.S. adults (aged ≥20 years) with diabetes consuming SSBs, per-capita kcal on the surveyed day and grams of sugar on the surveyed day, by beverage, NHANES 2003–2006***

Variable	All	Undiagnosed	Uncontrolled and diagnosed	Controlled and diagnosed
Consumed beverages on the surveyed day (%)				
Had SSB	45 ± 2	60 ± 4	38 ± 2*	43 ± 3*
Had diet	38 ± 2	18 ± 3	50 ± 3*	40 ± 3*
Caloric contribution (kcal/day)				
Per capita from SSB	86 ± 8	128 ± 20	65 ± 9*	78 ± 13*
Daily from SSB among drinkers	202 ± 12	225 ± 22	171 ± 18	207 ± 25
Sugar from SSB (g/day)	47 ± 3	54 ± 6	39 ± 5	48 ± 6

Data are mean ± SEM. Multivariate regression was used to adjust for race/ethnicity, sex, age, education, marital status, income, employment status, and obesity/overweight status. Percentage of U.S. population estimated using survey weights to adjust for unequal probability of sampling. *$P < 0.05$ indicates the difference from the reference group (undiagnosed).

For all subgroups in Table 3 (with the exception of income quartile 1 and body weight category overweight/obese), individuals who were undiagnosed consumed more grams of sugar daily from SSBs than individuals who were diagnosed, regardless of glycemic control.

CONCLUSIONS—Adults with diabetes are advised to limit their intake of beverages with added sugar (12). Yet, our study indicates that adults with diabetes consume considerable calories from SSBs. In 2003–2006, 45% of adults with diabetes drank SSBs, consuming 202 calories and 47 g of added sugar, an equivalent of about 12 teaspoons of sugar on a given day. In short, most adults with diabetes, particularly those who are undiagnosed, meet or exceed the daily recommended intake of sugar (7). Unsurprisingly, the percentage of SSB drinkers and quantity of SSBs consumed was significantly higher among adults who were undiagnosed compared with adults who were diagnosed. Our finding that individuals who were diagnosed consumed less SSBs compared with those who were undiagnosed suggests that messages about the importance low sugar intake are having a positive effect on dietary behavior among diagnosed individuals. Because SSBs are the largest single source of added sugar in the U.S. diet (13,14), reducing or eliminating SSB intake might be a concrete strategy for adults with diabetes to decrease consumption of added sugars for better glycemic control (15) as well as for better weight management (1).

An additional key finding from this study was the considerable difference in average SSB consumption among patients with diabetes in different demographic subgroups (16). Average daily grams of sugar from SSBs were significantly higher among men, young adults, blacks, and lower-income individuals. The steep decline in daily grams of sugar with age may be partially due to a cohort effect (i.e., younger generations have increased their SSB consumption) (8).

Our focus on individuals with diabetes makes it possible to highlight several potential opportunities to reduce SSB intake among this group as well as to identify concerning trends and patterns for future study. Higher SSB intake (and lower diet beverage intake) among adults who were undiagnosed compared with those who were diagnosed is consistent with the effort to improve diabetes control through patient education on dietary

Table 3—*Average grams of sugar from SSBs on the surveyed day among U.S. adults (aged ≥20 years) with diabetes by diagnosis and control, NHANES 2003–2006*

Variable	All	Undiagnosed	Uncontrolled and diagnosed	Controlled and diagnosed
Total	47 ± 3	54 ± 6	39 ± 5	48 ± 6
Sex				
Male	24 ± 3	37 ± 7	13 ± 4*	26 ± 6
Female	16 ± 2†	23 ± 6	14 ± 3	12 ± 3
Age (years)				
20–44	39 ± 6	53 ± 11	25 ± 9*	44 ± 15
45–64	21 ± 3†	30 ± 9	14 ± 2	20 ± 4
≥65	11 ± 1†	22 ± 4	9 ± 1*	9 ± 2*
Race/ethnicity				
Non–Hispanic white	19 ± 3	30 ± 6	12 ± 3*	18 ± 4
Non–Hispanic black	30 ± 3†	45 ± 17	24 ± 3	27 ± 6
Mexican American	14 ± 4	14 ± 6	10 ± 4	17 ± 7
Education				
Less than high school	19 ± 4	22 ± 8	16 ± 4	19 ± 8
High school or higher	20 ± 2	33 ± 6	12 ± 3*	19 ± 3*
Income				
Quartile 1 (lowest)	31 ± 6	26 ± 10	23 ± 8	38 ± 10
Quartile 2	20 ± 3	40 ± 9	13 ± 3*	13 ± 3*
Quartile 3	18 ± 2†	24 ± 6	14 ± 3	18 ± 4
Quartile 4 (highest)	13 ± 4†	26 ± 10	7 ± 4	13 ± 4
Body weight status				
Healthy weight (BMI <25) ‡	20 ± 2	32 ± 6	15 ± 3*	19 ± 3
Obese/overweight (BMI ≥25)‡	17 ± 3	20 ± 6	8 ± 3	26 ± 9

Data are mean ± SEM. Multivariate regression was used to adjust for race/ethnicity, sex, age, education, marital status, income, employment status, obesity/overweight status. Percentage of U.S. population estimated using survey weights to adjust for unequal probability of sampling. *$P < 0.05$ indicates the difference from the reference group (undiagnosed). †$P < 0.05$ indicates the difference from the reference group among all adults with diabetes. The reference groups for each category are: sex (male), race/ethnicity (white), education (less than high school), income (lower income), body weight status (healthy weight). ‡Healthy weight was defined as a BMI from 18.5 to 24.9 kg/m^2; overweight/obese, BMI ≥30 kg/m^2.

change. This result also points to the importance of improving the diagnosis of diabetes (and prediabetes) among high-risk populations, possibly in nontraditional clinical settings such as work places, churches, or mobile vans. Another might be to use incentives to encourage the purchase of noncaloric beverage alternatives rather than SSBs. Many incentives, such as price, point-of-purchase information, or product placement, have been shown to affect purchasing behavior (17,18). For example, reducing the price of low-fat snacks (relative to high-fat snacks) promoted lower-fat snack purchases (17).

The pattern for undiagnosed blacks and young adults is concerning. Blacks consumed an average of 45 g of sugar from SSBs daily (equivalent to 11 teaspoons of sugar) and young adults consumed an average of 53 g of SSBs daily (equivalent to 13 teaspoons of sugar), both of which are considerably more than the American Heart Association recommendation of no more than 25 g of added sugar per day for women and no more than 37.5 g for men (7). Blacks are also at higher risk for obesity (19), which has been linked to consumption of SSBs (20).

This study has four main limitations. First, our reliance on single 24-h dietary recalls to infer population dietary patterns may introduce inaccuracy and bias to our analyses due to underreporting, unreliability, and conversion error. Previous research indicates that adults underreport their dietary consumption by approximately 25% (21,22). However, available evidence also suggests better recall accuracy with packaged beverage items such as SSBs (23). A single 24-h dietary recall may be unreliable if it does not accurately represent an individual's overall dietary intake pattern. Lack of reliability of the 24-h recall data, with respect to overall eating habits, will reduce the precision of our estimates but will not bias our regression estimates where total energy intake is the dependent variable (24). There exists inaccuracy in converting reported beverage consumption to energy intake because the assumptions on serving size and food composition are defined by the food and nutrient database. Standard databases assume a "representative" nutritional content for a given beverage. Measurement error may be introduced because of reporting bias or the inevitable variation on actual intake. Diabetic individuals may be less likely to finish a SSB or may dilute it with water, which could lead to over-reporting of SSB intake among this group. However, such an error may be less significant when quantifying serving size and nutrient content for packaged, standard-sized beverages.

Second, although we used multivariate regression models to adjust for demographic variables, our inferences on beverage consumption patterns may remain confounded by other demographic variables uncontrolled for.

Third, the NHANES data are cross-sectional in nature, which only allows us to address associations rather than causality.

Finally, we partially relied on self-report to define diabetes. By using this method, we may have captured some individuals with type 1 diabetes. However, ~90% of the U.S. diabetes population has type 2 diabetes, so we do not suspect this significantly biased the results.

To conclude, SSB consumption is high among adults with diabetes, particularly among those who are undiagnosed. Efforts to encourage replacing SSB with low-caloric or noncaloric alternatives may be an important strategy to reduce consumption of "empty calories" among individuals with diabetes, particularly for blacks, young adults, and low-income individuals who have the highest levels of consumption. Lower SSB consumption among individuals who are diagnosed suggests that messages about the importance low sugar intake aimed at the diabetic population are having a positive impact. Physicians and public health professionals are well positioned to identify and promote concrete behavioral targets aimed at decreasing adult SSB consumption, making awareness of these trends critical among individuals with diabetes.

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S.N.B. conceived the study, developed the hypotheses, analyzed data, drafted the manuscript, and is the guarantor. Y.C.W. conceived the study, developed the hypotheses, and analyzed data. Both authors contributed to the interpretation of study findings and to the final draft.

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