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Trends in Added Sugars Intake and Sources Among US Children, Adolescents, and Teens Using NHANES 2001–2018

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ABSTRACT

Background: Over the past 2 decades, there has been an increased emphasis on added sugars intake in the Dietary Guidelines for Americans (DGA), which has been accompanied by policies and interventions aimed at reducing intake, particularly among children, adolescents, and teens.

Objectives: The present study provides a comprehensive time-trends analysis of added sugars intakes and contributing sources in the diets of US children, adolescents, and teens (2–18 years) from 2001–2018, focusing on variations according to sociodemographic factors (age, sex, race and ethnicity, income), food assistance, and health-related factors (physical activity level, body weight status).

Methods: Data from 9 consecutive 2-year cycles of the NHANES were combined and regression analyses were conducted to test for trends in added sugars intake and sources from 2001–2018 for the overall age group (2–18 years) and for 2 age subgroups (2–8 and 9–18 years). Trends were also examined on subsamples stratified by sex, race and ethnicity (Hispanic, non-Hispanic Asian, non-Hispanic Black, non-Hispanic White), income (household poverty income ratio), food assistance, physical activity level, and body weight status.

Results: From 2001–2018, added sugars intakes decreased significantly ($P < 0.01$), from 15.6% to 12.6% kcal among children (2–8 years) and from 18.4% to 14.3% kcal among adolescents and teens (9–18 years), mainly due to significant declines in added sugars from sweetened beverages, which remained the top source. Declines in added sugars intakes were observed for all strata, albeit to varying degrees.

Conclusions: Declines in added sugars intakes were observed among children, adolescents, and teens from 2001–2018, regardless of sociodemographic factors, food assistance, physical activity level, or body weight status, but variations in the magnitudes of decline suggest persistent disparities related to race and ethnicity and to income. Despite these declines, intakes remain above the DGA recommendation; thus, continued monitoring is warranted. *J Nutr* 2022;152:568–578.

Keywords: added sugars, trends, intake, sources, NHANES, United States, children, adolescents, teens

Introduction

There is global attention on reducing the intake of added sugars. In 2015, the WHO recommended <10% energy per day as "free sugars," which includes added sugars and those naturally present in honey, syrups, fruit juices, and fruit concentrates (1). Similarly, a recommendation of <10% energy per day from added sugars first appeared in the 2015 US Dietary Guidelines for Americans (DGA) and remains in the 2020 edition (2, 3). In contrast, prior DGA editions included more general statements on choosing foods to moderate the intake of sugars (in 2000), on choosing foods with little added sugars or caloric sweeteners (in 2005), or on reducing the intake of kcal from added sugars (in 2010) (2). The DGA have thus evolved to more quantitative recommendations over the past 2 decades regarding their advice on dietary sugars.

The increasing emphasis on added sugars intake in the DGA over time has been accompanied by the development of policies and interventions aimed at reducing intake, particularly for children, adolescents, and teens, who have the highest intakes (4–6); reducing their intake of sweetened beverages has also been a key focus (3). Furthermore, children, adolescents, and teens are a key target group for dietary interventions because their eating patterns tend to continue into adulthood, and a healthy dietary pattern at 1 life stage can support health into the next stage (3). Examinations of added sugars intakes in the United States have reported declining trends among children, adolescents, and teens over various time periods

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spanning 1994–2018 (7–11), mainly driven by declines in the consumption of sweetened beverages (6, 7, 10–14). Yet despite these trends, the majority of US children, adolescents, and teens exceed the recommendation on added sugars intake (3).

The US population is diverse; thus, observed trends in the added sugars intake for the overall population may mask differences among various population subgroups. Variations in added sugars intakes have been documented according to the sociodemographic factors of race and ethnicity and of income, with higher intakes among Black children, adolescents, and teens and among those in lower income groups (6, 8, 11, 12, 15, 16). Some households in lower income groups are eligible to receive government food assistance, and research suggests diet quality is lower among these households compared to higher-income households (17–19), but little is known about differences between these 2 groups in added sugars intake trends. Furthermore, health-related factors, such as physical activity level and body weight status, may also contribute to differences in added sugars intakes among US children, adolescents, and teens; however, the evidence is limited and may depend on the sources of added sugars (6, 20, 21).

The present study aims to provide a comprehensive time-trends analysis of added sugars intakes and contributing sources in the diets of US children, adolescents, and teens (2–18 years) from 2001–2018, focusing on variations according to the sociodemographic factors of age, sex, race and ethnicity, and income; food assistance; and the health-related factors of physical activity level and body weight status.

Methods

Data

Diet and health are monitored regularly in the United States through NHANES, a cross-sectional survey of the noninstitutionalized civilian resident population ≥2 years old. The survey sample is selected through a clustered, stratified, multistage sampling design, with periodic oversampling of select population groups in order to generate a nationally representative sample (22). The dietary interview component of NHANES, called What We Eat in America (WWEIA), consists of 2 nonconsecutive 24-hour recalls collected using the 5-step Automated Multiple Pass Method and administered by trained interviewers (23). Interviews are conducted with a proxy for children 2–5 years old and are proxy-assisted for children 6–11 years old. Details on the NHANES survey design and data collection procedures are reported elsewhere (22, 23).

In order to analyze trends over time in added sugars intakes among children, adolescents, and teens, data from 9 consecutive 2-year cycles of NHANES were combined, starting with the 2001–2002 cycle and ending with the 2017–2018 cycle. The final sample size of all individuals ≥2 years old was 72,829, after excluding those with missing or unreliable data (n = 10,163), pregnant or lactating females (n = 1631), and those reporting not eating any food or beverage (kcal = 0; n = 6). The final analytic sample size of children, adolescents, and teens aged 2–18 years was 28,257, with 11,626 children (2–8 years) and 16,631 adolescents and teens (9–18 years).

Added sugars intake

Food and beverages reported in the dietary 24-hour recalls can be converted to food pattern equivalents, corresponding to those in the DGA, using the USDA Food Patterns and Equivalents Database (FPED), which was called the My Pyramid Equivalents Database for the NHANES 2001–2002 cycle (24). The added sugars food pattern component is comprised of caloric sweeteners, using the definition of added sugars as "sugars that are added to foods as an ingredient during preparation, processing or at the table; and do not include naturally occurring sugars such as lactose present in milk and fructose present in whole or cut fruit and 100% fruit juice" (25). While this definition has been relatively stable over time, the categorization of fruit juice concentrates added as ingredients to foods has changed; concentrates were initially included in the fruit juice component and then assigned to the added sugars component starting with the NHANES 2011–2012 cycle (26). This change in categorization affected subsequent (2011 onwards) added sugars values for snack bars, ready-to-eat (RTE) cereals, baby foods, and fruit spreads; however, a USDA analysis demonstrated mean intake estimates of added sugars were not affected (26).

The added sugars intake was determined for each NHANES cycle using the cycle-specific FPED. Intake data from Day 1 were used to calculate the added sugars intake, as this is sufficient for providing an accurate estimate of the population mean intake (27), which was the focus of our analyses. Added sugars values provided as teaspoon equivalents in the FPED were converted to grams and kilocalories (4.2 g/tsp and 4.0 kcal/g, respectively). In order to account for differences in energy intake over time, the mean added sugars intake was expressed as a percentage of total daily kilocalories (% kcal) using the population ratio method (28), which involves summing the daily added sugars intake for all individuals in a particular age group and then dividing by the sum of the daily kilocalorie intakes for the same individuals. The population ratio method was chosen because it provides information about population intakes as a whole (29), and thus is directly relevant to our population-level analyses.

In order to further understand the trends in added sugars intakes over time, trends in food sources of added sugars were analyzed over the same time period. Sources of added sugars were based on WWEIA food categories, in which foods and beverages are grouped according to their similar nutrient contents and common use in the diet; individual food categories can be combined into larger food groups for analytical purposes (23). WWEIA food categories are updated with each NHANES cycle to reflect changes in food consumption patterns (30). The 2017–2018 WWEIA food categories were used for our analysis (**Table 1**). The mean added sugars intakes from the food sources, expressed as a percentage of the total daily added sugars intake, were calculated using the population ratio method; food sources were then ranked from highest to lowest contributors to added sugars intakes.

Statistical analyses

Data were analyzed using SAS 9.4 (SAS Institute), and weighting factors provided by NHANES were applied to the combined sample of the 9 NHANES cycles in order to adjust for the complex survey sampling design, sample design changes across survey cycles, nonresponse rates, and oversampling of certain subgroups. Linear and quadratic regression analyses were used to test for trends over time in added sugars intakes, with the estimated mean added sugars intake as the dependent variable and the NHANES cycle as the continuous independent variable. Linear regression analyses were also used to compare mean added sugars intakes in each NHANES cycle to the reference cycle of 2001–2002. The same analyses were conducted on food sources of added sugars, with those contributing at least 2% to the total daily added sugars intake,

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Abbreviations used: DGA, Dietary Guidelines for Americans; FPED, Food Patterns and Equivalents Database; PIR, poverty income ratio; RTE, ready-to-eat; WWEIA, What We Eat in America.

TABLE 1 Breakdown of food groups into types of foods that provide added sugars[1]

Food Group	Food Category
Breads, Rolls, Tortillas	Yeast breads; rolls and buns; bagels and english muffins; tortillas
Candy	Candy: containing chocolate; not containing chocolate
Coffee and Tea	Coffee; tea
Fats and Oils	Butter and animal fats; margarine; cream cheese, sour cream, whipped cream; cream and cream substitutes; mayonnaise; salad dressings and vegetable oils
Flavored Milk	Flavored milk: whole; reduced fat; low fat; nonfat
Other Desserts	Ice cream and frozen dairy desserts; pudding; gelatins, ices, sorbets
Quick Breads and Bread Products	Biscuits, muffins, quick breads; pancakes, waffles, french toast
Ready-to-Eat Cereals	RTE cereal: higher sugar (>21.2 g/100 g); lower sugar (≤21.2 g/100 g)
Sugars	Sugars and honey; sugar substitutes; jams, syrups, toppings
Sweet Bakery Products	Cakes and pies; cookies and brownies; doughnuts, sweet rolls, pastries
Sweetened Beverages	Soft drinks; fruit drinks; sport and energy drinks; nutritional beverages; smoothies and grain drinks
Yogurt	Yogurt: regular; Greek

[1]Types of foods were based on WWEIA categories (23). RTE, ready-to-eat; WWEIA, What We Eat in America.

based on data from NHANES 2001–2002, considered for analysis. All analyses were conducted on children, adolescents, and teens overall (2–18 years) and in 2 age subgroups (2–8 and 9–18 years). A P value < 0.01 was considered statistically significant.

In order to assess variations in trends over time according to other sociodemographic factors, food assistance, and health-related factors, the sample was further stratified by: sex; race and ethnicity, using the NHANES categories of Hispanic, non-Hispanic Asian (hereafter, Asian), non-Hispanic Black (hereafter, Black) and non-Hispanic White (hereafter, White); household poverty income ratio (PIR), categorized as low, medium, and high ($PIR < 1.35$, $1.35 \leq PIR \leq 1.85$, and $PIR > 1.85$, respectively); food assistance, categorized as either Yes or No in response to the NHANES survey question about the household receiving food assistance in the past 12 months; physical activity level, categorized as sedentary, moderate, or vigorous based on the number of days in which vigorous exercise was performed using the NHANES physical activity questionnaire responses (0–3, 4–6, and 7 days per week, respectively); and body weight status, categorized as normal (BMI, 5th to <85th percentile), overweight (BMI, 85th to <95th percentile), or obese (BMI ≥ 95th percentile). Trends in intakes of added sugars were examined in all strata for each age group, and trends in food sources were examined in all strata only for the overall age group (2–18 years) so as to have a large enough sample size. For the Hispanic and Asian ethnic groups, nationally representative data were only available starting with the NHANES 2007–2008 and 2011–2012 cycles, respectively; trend analyses for these 2 groups were thus conducted on the combined sample from 2011–2018 to facilitate direct comparisons.

Results

Added sugars intake trends over time

Added sugars intakes decreased significantly over time among all age groups, beginning in 2007 for the absolute quantity of added sugars intake (g/d) and in 2009 for the added sugars intake relative to total daily kilocalories (% kcal; **Figure 1**). The decreasing trends for absolute intakes differed in magnitude between the 2 age subgroups, with an average 2.5 g decrease in added sugars intake with every cycle among children (2–8 years) and an average 4.4 g decrease among adolescents and teens (9–18 years), representing overall declines of 23% and 28%, respectively, from 2001–2018 (**Supplemental Table 1**). For relative intakes, added sugars declined from 15.6% kcal to 12.6% kcal among children and from 18.4% kcal to 14.3% kcal among adolescents and teens, representing overall declines in magnitude of 20% and 22%, respectively (**Supplemental Table 2**).

The decreasing trends in added sugars intakes from 2001–2018 could be largely attributed to decreasing trends in added sugars from sweetened beverages, as their contributions to total daily added sugars intakes decreased significantly for both age subgroups, from 35.2% to 22.8% among children (**Table 2**) and from 47.7% to 33.5% among adolescents and teens (**Table 3**), although sweetened beverages remained the number 1 source of added sugars. Sweet bakery products were the second highest source of added sugars, and their contribution increased significantly for both age subgroups. Furthermore, among children, added sugars contributions from the other desserts and candy sources changed by a similar degree over time, but in opposite directions, with the contribution from other desserts falling and the contribution from candy rising. Among adolescents and teens, there was a significant curvilinear trend in the added sugars contribution from RTE cereals, with the added sugars contribution decreasing initially (2001–2008) and increasing later (2009–2018). Also among adolescents and teens, the added sugars contribution from coffee and tea increased significantly over time, from 2.5% in NHANES 2001–2002 to 6.8% in 2017–2018, although the increase was not high enough to offset the decline in added sugars from sweetened beverages.

Variation by sex

Significant decreasing trends in added sugars intakes over time were similar for males and females in both age subgroups; however, 3 sex differences in trends in food source contributions were apparent [beta coefficient (β) ± SE, % total daily added sugars per cycle]: there was a significant increase in the added sugars contribution from candy among females 2–8 years ($\beta = 0.52 \pm 0.14$), but not males; a significant increase in the added sugars contribution from sweet bakery products among females 9–18 years ($\beta = 0.48 \pm 0.13$), but not males; and a significant curvilinear trend (decreasing initially and increasing later) in the added sugars contribution from RTE cereals among males 9–18 years ($\beta_1 = -1.23 \pm 0.22$; $\beta_2 = 0.14 \pm 0.02$), but not females (data not shown).

Variation by race and ethnicity, income, and food assistance

In general, significant decreasing trends in added sugars intakes (% kcal) over time were observed for all ethnic groups, depending on the age group (**Figure 2**A; **Supplemental Table 3**). Among Asian individuals, decreasing trends were significant

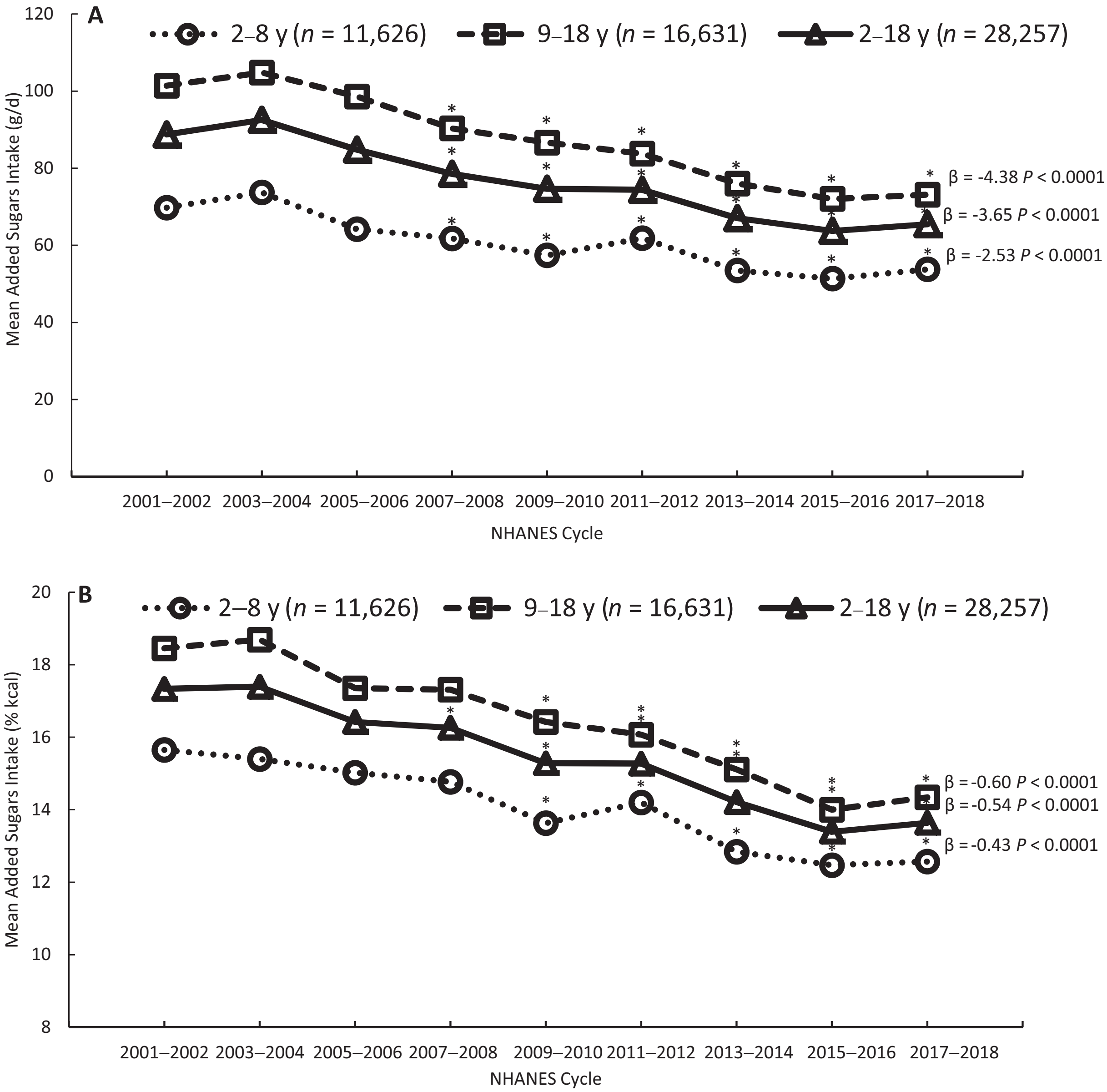

FIGURE 1 Added sugars intake (A) in grams per day (g/d) and (B) percentage of total daily kilocalories (% kcal) among children, adolescents, and teens, 2001–2018, based on the first day of dietary recall. The β and P values are from a linear trend analysis. ∗Significantly different from reference cycle (NHANES 2001–2002) and test for trend significant at a P value < 0.01.

only in children (2–8 years); among Hispanic individuals, decreasing trends were significant only in the overall age group (2–18 years). At the first NHANES cycle, White children, adolescents, and teens had the highest added sugars intakes compared to other ethnic groups, and a steeper decline in added sugars intakes (20% for both age subgroups) compared to Black (6% and 15% for those 2–8 and 9–18 years, respectively) and Hispanic (12% for those 2–18 years) individuals; by 2017–2018, Black individuals had the highest added sugars intake compared to other ethnic groups, and White individuals had the second highest. Asian individuals had the lowest added sugars intake of all ethnic groups and the greatest decline in added sugars intake (22% for those 2–8 years).

The decreasing trends in added sugars intakes among Black and White children, adolescents, and teens could be attributed to significant decreasing trends in the added sugars contributions from sweetened beverages; however, sweetened beverages still remained the top source of added sugars (**Supplemental Table 4**). The category of coffee and tea was in the list of top added sugars contributors among all ethnicities except Black individuals, with the contributions increasing over time among Asian, Hispanic, and White individuals, but not significantly (P = 0.0181, 0.3131, and 0.0151, respectively). The added sugars contributions from sweet bakery products also increased for all ethnic groups, but was significant only among Black individuals (P = 0.0368, 0.0433, and 0.0324 among Asian, Hispanic, and White individuals, respectively). A significant curvilinear trend (decreasing initially and increasing later) in the added sugars contribution from RTE cereals was apparent only among White individuals.

Significant decreasing trends in added sugars intakes (% kcal) over time were also observed among all PIR and food assistance groups, with the magnitude of decline varying across these groups (Figure 2B and C; Supplemental Table 3). In

TABLE 2 Trends in sources of added sugars among children (2–8 years; $n = 11{,}626$), 2001–2018: food group contributions as a percentage of total daily added sugars intake[1]

Food Group[2]	Sweetened Beverages		Sweet Bakery Products		Other Desserts		Ready-to-Eat Cereals		Candy		Flavored Milk		Sugars		Breads, Rolls, Tortillas		Yogurt	
Year	Mean[3] (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P
2001–2002	35.2 (1.7)		14.3 (1.2)		9.4 (1.1)		7.7 (0.5)		6.4 (0.4)		6.2 (0.6)		4.9 (0.5)		2.3 (0.1)		2.2 (0.4)	
2003–2004	35.9 (1.4)	0.7221	11.4 (0.9)	0.0465	9.9 (1.3)	0.7340	8.0 (0.5)	0.7054	6.1 (0.6)	0.6324	5.7 (0.6)	0.5583	7.1 (1.1)	0.0591	1.9 (0.1)	0.0124	2.3 (0.5)	0.8291
2005–2006	29.5 (1.8)	0.0198	14.5 (1.0)	0.9032	12.3 (1.4)	0.0986	8.2 (0.4)	0.4381	8.0 (1.1)	0.1689	5.0 (0.6)	0.1612	6.4 (0.5)	0.0234	2.0 (0.1)	0.0457	2.3 (0.2)	0.8373
2007–2008	30.6 (1.2)	0.0248	13.6 (0.8)	0.6140	10.1 (0.8)	0.5735	6.5 (0.5)	0.0686	8.0 (0.8)	0.0609	7.4 (0.7)	0.1975	4.9 (0.4)	0.9226	1.9 (0.1)	0.0146	1.9 (0.3)	0.5677
2009–2010	29.5 (1.0)	0.0040[4]	13.4 (0.7)	0.4832	8.8 (0.9)	0.7012	7.0 (0.5)	0.2801	7.3 (0.6)	0.1511	8.2 (0.8)	0.0411	5.1 (0.5)	0.7686	2.6 (0.2)	0.0887	3.1 (0.5)	0.1622
2011–2012	29.3 (1.5)	0.0089[4]	15.4 (0.8)	0.4403	7.7 (0.9)	0.2591	6.6 (0.4)	0.0751	7.0 (0.9)	0.5129	6.3 (0.8)	0.9563	6.3 (0.9)	0.1769	1.8 (0.1)	0.0001[4]	3.6 (0.6)	0.0346
2013–2014	23.9 (1.8)	<0.0001[4]	16.3 (1.1)	0.2157	7.8 (0.5)	0.2090	7.2 (0.7)	0.5123	12.4 (1.8)	0.0012[4]	5.8 (0.6)	0.6427	4.5 (0.4)	0.5881	2.4 (0.3)	0.7431	3.0 (0.5)	0.1587
2015–2016	24.6 (1.4)	<0.0001[4]	18.0 (1.1)	0.0205	7.8 (1.0)	0.3149	7.0 (0.5)	0.2830	9.2 (0.9)	0.0035[4]	6.3 (0.7)	0.9439	5.0 (0.7)	0.9127	1.5 (0.2)	0.0001[4]	1.7 (0.3)	0.2614
2017–2018	22.8 (1.6)	<0.0001[4]	19.2 (1.0)	0.0019[4]	7.1 (0.8)	0.0857	7.2 (0.6)	0.5266	9.5 (1.0)	0.0043[4]	6.1 (0.7)	0.9490	3.3 (0.4)	0.0124	1.4 (0.2)	<0.0001[4]	2.1 (0.3)	0.8822
Linear Trend[5]	−1.62 (0.21)	0.0001[6]	0.80 (0.19)	0.0046[6]	−0.45 (0.12)	0.0069[6]	−0.15 (0.08)	0.0923	0.39 (0.10)	0.0063[6]	0.04 (0.12)	0.7321	−0.26 (0.10)	0.0378	−0.07 (0.04)	0.1089	−0.02 (0.06)	0.7063

[1]Data are from sources contributing at least 2% to TAS in reference cycle NHANES 2001–2002. TAS, total added sugars.
[2]Based on 2017–2018 What We Eat in America food groups.
[3]Based on intake data from Day 1.
[4]Significantly different ($P < 0.01$) from reference cycle NHANES 2001–2002.
[5]Data are shown as betas (SEs) and P values.
[6]Significant ($P < 0.01$) linear trend.

2001–2002, the high PIR group had the highest added sugars intake and the low PIR group had the lowest intake; however, the high PIR group had the steepest decline in added sugars intake, so that by the last cycle (2017–2018) the positions switched, with the highest added sugars intake among the low PIR group and the lowest intake among the high PIR group. A similar pattern was observed for food assistance; those who did not receive food assistance had a higher added sugars intake in 2001–2002, but due to a steeper decline over time among this group, the intakes among both food assistance groups were similar by 2017–2018.

These trends among PIR and food assistance groups could be attributed to significant, decreasing trends in the added sugars contributions from sweetened beverages observed among all groups, with greater declines among the medium and high PIR groups and those who did not receive food assistance (**Supplemental Table 5**). Significant increases over time in the relative contribution from coffee and tea were apparent among the low PIR group and those who did not receive food assistance. Furthermore, in the medium PIR group only, there was a significant increase in the contribution from candy, and a curvilinear trend (decreasing initially and increasing later) in the contribution from RTE cereals.

Variation by physical activity level and body weight status

Significant, decreasing trends in added sugars intakes over time were observed among all physical activity level and body weight status groups (**Figure 3**; Supplemental Table 3). The magnitude of decline varied across physical activity level groups, with the steepest decline apparent for those in the vigorous activity group, who went from the second highest added sugars intake in 2001–2002 (the moderate activity group had the highest) to the lowest intake by 2017–2018, while the magnitude of decline was similar across body weight status groups. These decreasing trends in added sugars intakes could be attributed to significant declines in the added sugars contributions from sweetened beverages among all groups (**Supplemental Tables 6** and 7). In contrast, there were significant increases over time in the relative contribution from coffee and tea, which were observed only among the vigorous activity and obese body weight status groups.

Discussion

We observed declines in added sugars intakes, both in absolute (g) and relative (% kcal) measures, among US children, adolescents, and teens, which occurred mainly from 2009–2018. These findings are consistent with those from other reports of decreasing trends among this same age group in the United States (7–11), and also align with US food disappearance data showing declines in per capita availability of added sugars from 2001–2018 (31). Similar observations of decreasing added sugars intakes have been documented among children, adolescents, and teens in other developed countries (32–35). Our results also demonstrate that added sugars intakes declined across various strata: regardless of age, sex, race and ethnicity, income, food assistance, physical activity level, or body weight status, intakes decreased over time, albeit to varying degrees, consistent with other studies examining various of these factors (7, 8, 10, 11, 13, 14, 18).

Our findings on the sources of added sugars among US children, adolescents, and teens reveal that declines in

TABLE 3 Trends in sources of added sugars among adolescents and teens (9–18 years; $n = 16{,}631$), 2001–2018: food group contributions as a percentage of total daily added sugars intake[1]

Food Group[2]	Sweetened Beverages		Sweet Bakery Products		Other Desserts		Candy		Ready-to-Eat Cereals		Sugars		Flavored Milk		Coffee and Tea	
Year	Mean[3] (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P	Mean (SE) % TAS	P
2001–2002	47.7 (1.3)		11.1 (0.8)		7.6 (0.6)		7.0 (0.5)		6.2 (0.5)		5.1 (0.6)		2.7 (0.2)		2.5 (0.4)	
2003–2004	51.5 (1.1)	0.0213	10.9 (0.7)	0.8800	6.5 (0.7)	0.2691	6.1 (0.6)	0.2626	5.3 (0.4)	0.1241	4.7 (0.4)	0.5886	2.2 (0.3)	0.2123	2.4 (0.4)	0.8376
2005–2006	49.3 (1.9)	0.4699	11.9 (0.9)	0.4992	7.1 (0.9)	0.6414	6.7 (0.6)	0.6445	4.7 (0.3)	0.0086[4]	4.4 (0.7)	0.4144	2.2 (0.3)	0.1544	2.5 (0.5)	0.9795
2007–2008	45.1 (1.9)	0.2694	10.8 (0.9)	0.8288	8.5 (1.1)	0.4563	7.6 (0.6)	0.5001	4.7 (0.3)	0.0111	4.7 (0.5)	0.6333	2.4 (0.3)	0.4632	3.7 (0.6)	0.0925
2009–2010	43.1 (1.9)	0.0464	11.6 (0.6)	0.5868	7.7 (0.6)	0.8683	6.0 (0.5)	0.1433	5.0 (0.5)	0.1011	3.7 (0.4)	0.0504	3.4 (0.4)	0.0905	5.1 (1.2)	0.0432
2011–2012	40.2 (1.6)	0.0003[4]	13.1 (0.9)	0.0856	5.8 (1.1)	0.1489	6.0 (1.1)	0.3709	5.2 (0.4)	0.1063	5.3 (1.0)	0.8278	2.7 (0.3)	0.9565	7.1 (1.2)	0.0002[4]
2013–2014	40.2 (1.9)	0.0010[4]	11.9 (1.2)	0.5652	5.4 (0.4)	0.0024[4]	7.1 (0.6)	0.9776	5.2 (0.5)	0.1229	4.7 (0.4)	0.5472	2.5 (0.4)	0.6487	7.7 (1.9)	0.0085[4]
2015–2016	33.9 (1.4)	<0.0001[4]	14.2 (1.1)	0.0195	6.2 (0.8)	0.1605	8.7 (1.1)	0.1760	6.3 (0.6)	0.9494	5.0 (0.5)	0.9211	2.6 (0.3)	0.8428	6.4 (1.1)	0.0008[4]
2017–2018	33.5 (1.3)	<0.0001[4]	14.3 (1.2)	0.0212	6.5 (0.9)	0.3285	7.4 (0.8)	0.6752	6.8 (0.6)	0.4661	5.1 (0.7)	0.9811	2.6 (0.3)	0.7501	6.8 (0.9)	<0.0001[4]
Linear Trend[5]	−2.24 (0.27)	0.0001[6]	0.39 (0.10)	0.0061[6]	− 0.25 (0.11)	0.0588	0.07 (0.10)	0.5015	0.10 (0.10)	0.3250[7]	0.01 (0.08)	0.9320	0.01 (0.04)	0.7251	0.63 (0.10)	0.0004[6]

[1]Contributing at least 2% to TAS in reference cycle NHANES 2001–2002. TAS, total added sugars.
[2]Based on 2017–2018 What We Eat in America food groups.
[3]Based on intake data from Day 1.
[4]Significantly different ($P < 0.01$) from reference cycle NHANES 2001–2002.
[5]Data are shown as betas (SEs) and P values.
[6]Significant ($P < 0.01$) linear trend.
[7]Significant quadratic trend, $Beta_1 = -0.97$ (0.15; $P = 0.0007$) and $Beta_2 = 0.11$ (0.01; $P = 0.0003$).

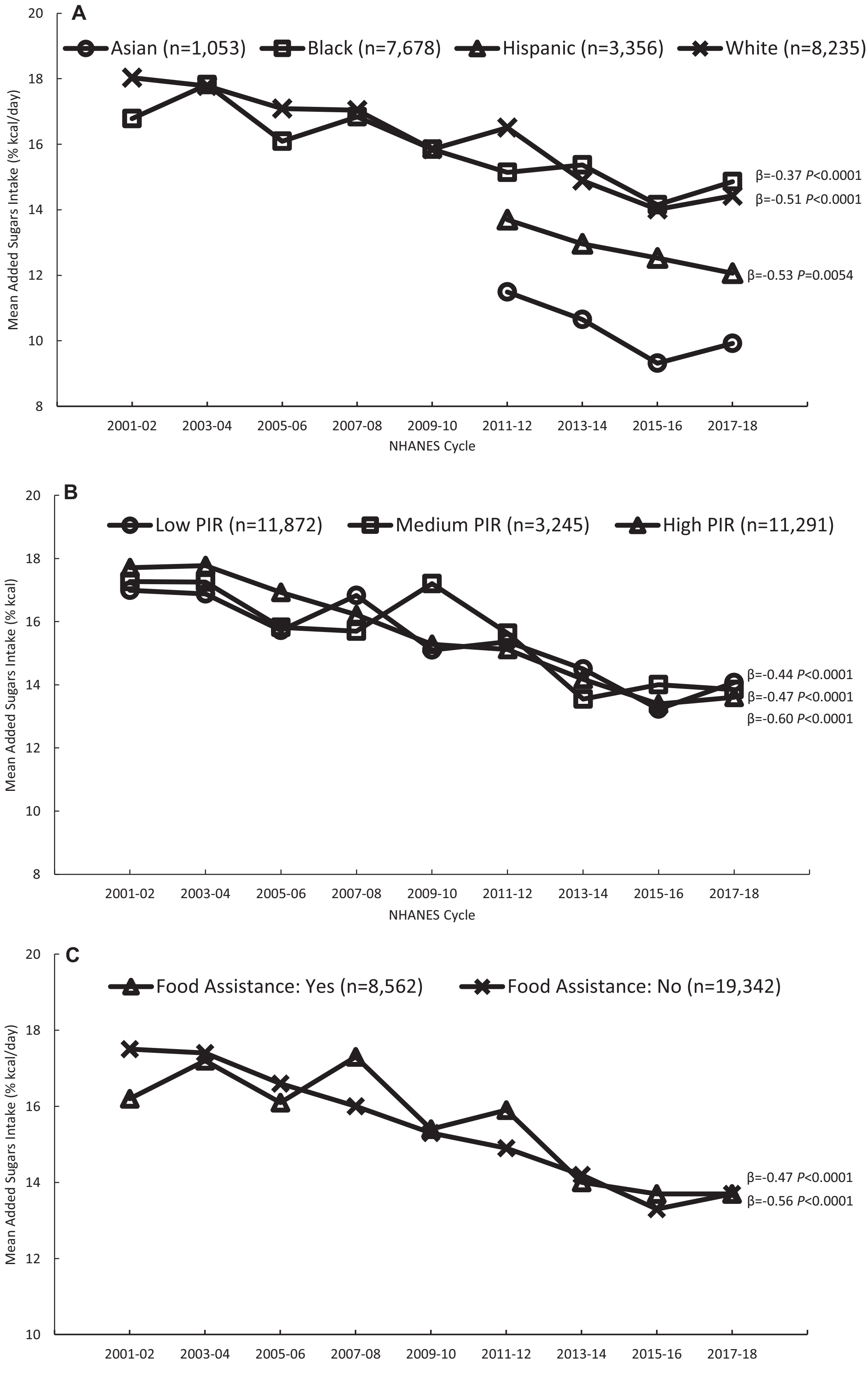

FIGURE 2 Added sugars intake among children, adolescents, and teens (2–18 years), 2001–2018, by (A) race and ethnicity, (B) income, and (C) food assistance, based on the first day of dietary recall. The β and P values are from a linear trend analysis. Values are significant at $P < 0.01$. Data from 2011–2018 for Hispanic and Asian individuals were used to facilitate direct comparisons because nationally representative samples were available starting in 2007–2008 and 2011–2012, respectively. PIR categories were set as low (PIR < 1.35), medium (1.35 ≤ PIR ≤ 1.85), and high (PIR > 1.85). PIR, poverty income ratio.

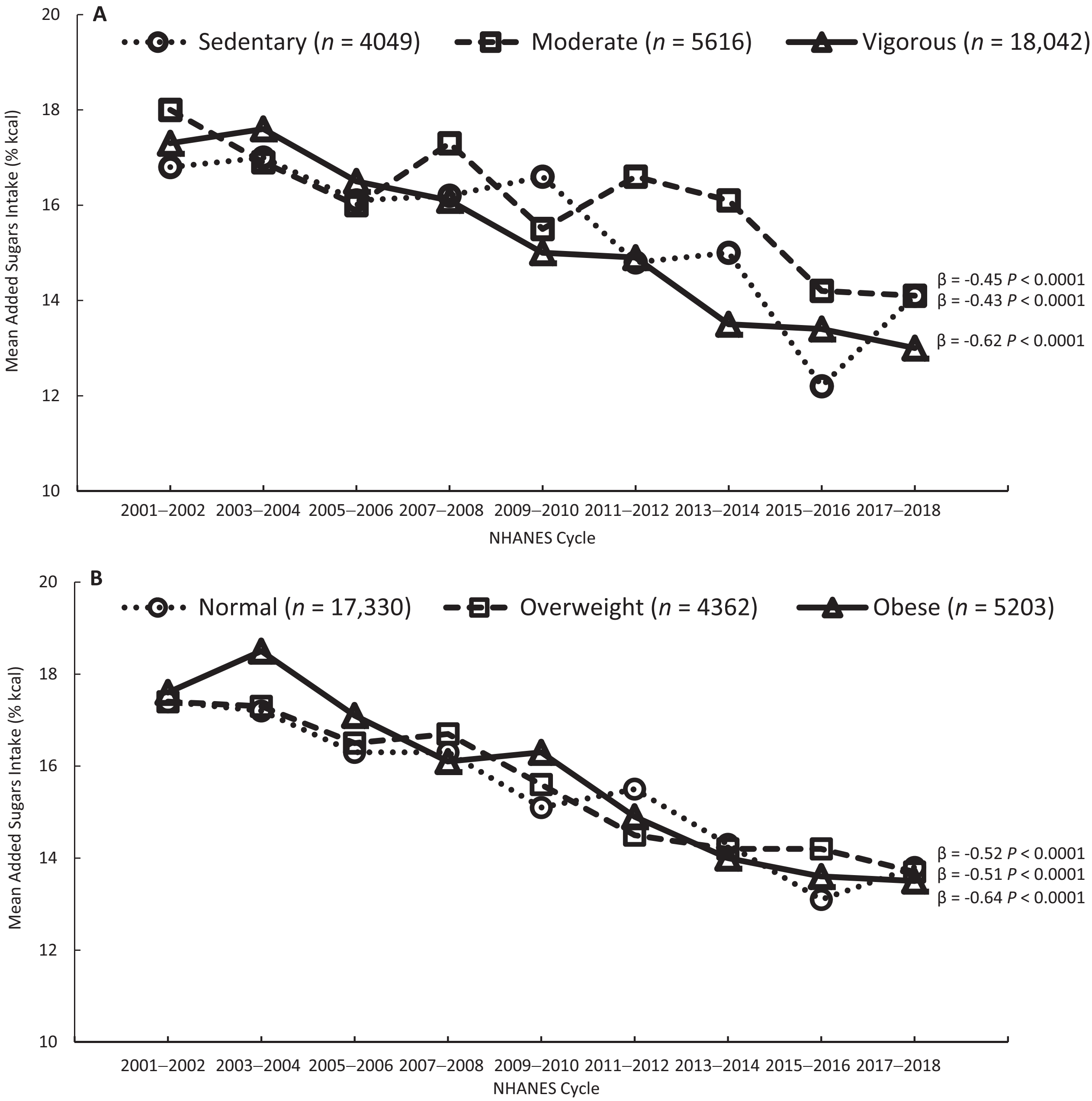

FIGURE 3 Added sugars intake among children, adolescents, and teens (2–18 years), 2001–2018, by (A) physical activity level and (B) body weight status, based on the first day of dietary recall. The β and P values are from a linear trend analysis. Values are significant at $P < 0.01$.

intakes were mainly due to declines in added sugars from sweetened beverages, which remained the top source of added sugars among children, adolescents, and teens over the entire time span (2001–2018). Other research on trends in beverage consumption using NHANES data has shown that the percentage of those aged 2–18 years drinking sweetened beverages has declined over time (10, 12, 14), including the percentage of heavy drinkers (≥500 kcal/d) (13), and that the energy contribution (kcal) from sweetened beverages among children, adolescents, and teens has also declined, mainly driven by decreases in soft drink and fruit drink consumption (12, 14). Reductions in the sugar content of some sweetened beverages may have contributed to some of our observed declines, as suggested by analyses of household purchasing data showing shifts over time from the purchase of beverages with caloric sweeteners towards the purchase of beverages containing a mixture of both caloric and noncaloric sweeteners (36).

Despite the decline in sweetened beverages, our results showed an increase in added sugars from coffee and tea beverages among adolescents and teens from 2001–2018, consistent with analyses of NHANES data by other researchers (14). Other sources of added sugars that increased over time include sweet bakery products, which remained the second highest source of added sugars; candy among children; and RTE cereals among adolescents and teens in 2009 and onwards. Part of the increase in added sugars from RTE cereals could be explained by the inclusion of fruit juice concentrates in the added sugars calculation, which also started in later NHANES cycles (2011 onwards), as this change for fruit juice concentrates has been shown to affect added sugars values of RTE cereals (26). Yet the overall trends we observed in added sugars sources suggest there were shifts in consumption among a variety of sources, which together resulted in the decline in added sugars intakes. In terms of consistencies over time, sweetened beverages and sweet bakery products remained the top sources of added sugars; the lowest contributors remained breads, rolls, tortillas, and yogurt among children and flavored milk among adolescents and teens, all of which made minimal contributions to added sugars intakes.

The declining trends in added sugars intakes that we observed among US children, adolescents, and teens began mainly in 2009, roughly coinciding with the implementation of reforms to national school lunch and breakfast programs aimed at improving the nutritional quality of foods in schools beginning in 2010 (37). Research examining diet quality trends from 2003–2018 has shown that the proportion of those aged 5–19 years consuming food with poor diet quality in schools has decreased from 56% to 24%, partly due to declines in sweetened beverages and added sugars consumption, and these improvements largely occurred after 2010 (11). A combination of school-based reforms, along with changes to foods and beverages consumed at home, where the majority of calories are consumed (11), likely contributed to the declining trends we observed and perhaps also reflected the evolving emphasis in the DGA on reducing the added sugars intake. Nevertheless, as we also saw, the added sugars intake among US children, adolescents, and teens remained above the DGA recommendation of <10% energy per day.

We observed declines in added sugars intakes across all strata, whether defined by age, sex, race and ethnicity, income, food assistance, physical activity level, or body weight status; however, the magnitudes of decline varied and, in some cases (sex and body weight), only the contributing sources varied. Among the different race and ethnicities, the greatest decline in added sugars intake was observed among White individuals; for income, those in the high PIR group had the greatest decline in added sugars intake; and those not receiving food assistance had a greater decline than those who received food assistance. Similar variations have been documented in other time-trend analyses of NHANES data (7, 8, 10, 11, 13, 14, 18). Overall, the different levels of decline resulted in disparities in added sugars intakes by race and ethnicity and by income, such that by 2018, intakes were highest among Black children, adolescents, and teens and among those in the low PIR group, similar to the results of other studies (15, 16, 38). In contrast, by 2018, added sugars intakes were similar among those receiving and not receiving food assistance, concordant with the results of studies comparing diet quality between these 2 groups (17). Taken together, these patterns suggest there may be cultural and socio-structural factors, as well as accessibility to resources, influencing trends in added sugars intakes.

Our study provides a comprehensive analysis of trends in added sugars intakes, combined with trends in the top sources of added sugars, among US children, adolescent, and teens. It also provides an analysis of variations in these trends according to sociodemographic factors, including age, sex, race and ethnicity, and income, all based on a nationally representative sample. Furthermore, we analyzed variations in added sugars intake trends according to food assistance and the health-related factors of physical activity level and body weight status, for which there is limited research, and thus our study fills an important research gap. The regular cycles of NHANES and corresponding databases, as well as the consistent NHANES survey design, allowed us to combine individual survey cycles and conduct a rigorous examination of trends over a time span from 2001–2018, which is a period of time over which the DGA also evolved in their recommendations on added sugars. Even for Asian and Hispanic individuals, where analyses were limited by when nationally representative data were available (2011–2018), the trends we observed over this time frame can serve as a baseline.

Our study has some limitations. The lack of data available for the entire time span from 2001–2018 for Asian and Hispanic individuals limited our comparisons among different ethnicities. It is also possible the intakes we observed may have been underestimated due to the use of proxies to collect dietary intake data for young children aged 2–5 years, as proxies tend to underestimate portion sizes (39), and because foods and beverages high in added sugars are more prone to underreporting compared to other sources (40–42). Furthermore, dietary intake data are subject to errors of misreporting. Variations in misreporting energy intakes have been documented among different age, ethnic, and income groups, and among different groups defined by body weight status (43); such variations could have impacted our analyses of subsamples stratified by these characteristics, but this impact was minimized by expressing added sugars intake as a percentage of energy intake. Lastly, as NHANES data are cross-sectional, we cannot infer causality for added sugars intake trends.

In conclusion, the added sugars intake has declined over the time span from 2001–2018 among US children, adolescents, and teens, mainly due to decreases in added sugars from calorically sweetened beverages (excluding coffee and tea). While declines in added sugars intakes were observed among both sexes and all ethnic groups, income groups, physical activity levels, and body weight status groups, and were observed regardless of whether or not a household received food assistance, variations in the rates of decline and shifts in consumption among added sugars sources suggest cultural and socio-structural factors and accessibility to resources may have some influence on added sugars trends. Despite the declines, the added sugars intake among US children, adolescents, and teens remains above the DGA recommendation of <10% energy per day, and consumption among various sources of added sugars has shifted (with both increases and decreases); therefore, continued monitoring of added sugars intakes and sources is warranted.

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Data Availability

The data used in this study are openly available in the NHANES website: NHANES Questionnaires, Datasets, and Related Documentation https://wwwn.cdc.gov/nchs/nhanes/Default.aspx.

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