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Consumption of Low-Calorie Sweeteners among Children and Adults in the United States

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Abstract

Background—Consumption of low-calorie sweeteners (LCSs) has increased markedly during the past several decades, yet the prevalence of LCS consumption in recent years is currently unknown.

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Supplementary materials:
Table 3 is available at www.andjrnl.org.
Podcast available at www.andjrnl.org/content/podcast

STATEMENT OF POTENTIAL CONFLICT OF INTEREST
No potential conflict of interest was reported by the authors.

Objective—The aim of this study was to describe LCS consumption in the United States and to characterize consumption by sociodemographic subgroups, source, frequency, eating occasion, and location.

Design—Cross-sectional study using National Health and Nutrition Examination Survey data from 2009 to 2012. The prevalence of LCS consumption was assessed using two 24-hour dietary recalls, while the frequency (number of times per day), occasion (meal vs snack vs alone), and location of LCS consumption (at home vs away from home) was assessed using data from the one, in-person, 24-hour dietary recall.

Participants—National Health and Nutrition Examination Survey participants (2 years old or older) either in 2009–2010 (n=9,047) or in 2011–2012 (n=7,939). After excluding participants with implausible energy intake (n=44), the final sample size was 16,942.

Main outcome measures—The primary outcome was the proportion of individuals consuming one or more foods, beverages, or packets containing LCSs during at least one of their two dietary recalls.

Statistical analyses performed—Data were weighted to provide national estimates and Stata frequency procedures for complex survey design were used for all analyses.

Results—Our findings were that 25.1% of children and 41.4% adults reported consuming LCSs. Most LCS consumers reported use once daily (80% of children, 56% of adults) and frequency of consumption increased with body weight in adults. LCS consumption was higher in females compared with males among adults, and in obese individuals, compared with overweight and normal-weight individuals. Individuals of non-Hispanic white race/ethnicity also had higher prevalence of consumption compared with non-Hispanic blacks and Hispanics and those in the highest tertile of income had higher LCS consumption compared with individuals of middle or low income across LCS product categories in adults, and for LCS beverages and LCS foods in children. Most LCS consumers reported consuming LCS with meals (64% of adults, 62% of children) and the majority of LCS consumption occurred at home (71% and 72% among adults and children, respectively).

Conclusions—LCS consumption is highly prevalent in the United States, among both children and adults. Well-controlled, prospective trials are required to understand the health impact of this widespread LCS exposure.

Keywords

Artificial sweeteners; Beverages; Diabetes; Diet soda; Obesity

LOW-CALORIE SWEETENERS (LCSS) ARE OFTEN USED in place of added sugars such as sucrose and high-fructose corn syrup in food and beverage products. Currently, six different LCSs are approved by the Food and Drug Administration (FDA) for use in the United States as food additives, including acesulfame-potassium, advantame, aspartame, neotame, saccharin, and sucralose.[1] In addition, stevioside and rebaudioside A, extracts of the *Stevia rebaudiana* Bertoni plant are used and regulated as dietary supplements.

Although LCSs were once believed to be metabolically inert, more recently their use has become controversial.[9] Some studies have suggested a beneficial effect on weight loss,[10–12] while others indicate that obesity risk increases with LCS use.[13] Little is known about the impact of long-term consumption, particularly in children. Despite the perceived benefits of replacing caloric sugars with LCSs for weight loss, evidence for the effectiveness of this strategy is lacking. Because how and by whom LCSs are consumed likely influences their role in weight managem ent and chronic disease, it is important to determ ine the prevalence of LCS consumption across sociodemographic subgroups and to evaluate the circumstances associated with their use. This information will ultimately inform the design, interpretation, and generalizability of future intervention studies conducted to better understand their health effects.

Several studies have reported increases in LCS use over the past 3 decades.[10–12] Mattes and Popkin first documented increasing LCS consumption in the US population betw een 1989 and 20 0 4. Marked increases in LCS use were then reported in both children and adults between 1999–2000 and 2007–2008, with consumption prevalence rising from 26.9% to 32.0% in adults and from 8.7% to 14.9% in children. This analysis also dem onstrated that consumption of commercially available beverages containing LCSs was driving the overall increase in LCS use. Recently, Drewnowski and Rehm examined sociodemographic correlates of LCS use from 1999 to 2008 and showed that LCS intake was highest among individuals with higher socioeconom ic status, non-Hispanic white individuals, females, and overweight and obese individuals. In addition, a report estimating the prevalence of diet drink consumption using National Health and Nutrition Examination Survey (NHANES) data from 2009 to 2010 documented that 20% of children and adults consumed commercially available diet drinks.

Piernas and colleagues and Ng and colleagues have also examined intake of LCS-containing foods and beverages using NHANES 2003–2010[14] and household purchase data from 2000–2010.[9] Another study by the same group assessed consumption of LCS-containing foods in 2003 to 2010 in relation to diet quality. These studies significantly contributed to our understanding of LCS consumption by examining sociodemographic differences in the prevalence of LCS consumption, primarily at the household level. The present analysis adds to this literature by updating and expanding on these findings by assessing the prevalence and frequency of LCS consumption by source (commercially available foods and beverages vs consumer-added packets), and by circumstance (meal occasion, location) across sociodemographic subgroups and weight status using recent NHANES data collected in 2009 to 2012.

MATERIALS AND METHODS

This analysis comprised data from two cycles of the NHANES, 2009–2010 and 2011–2012. NHANES is a continuous, crosssectional study of the US population, with data released in 2-year cycles. NHANES sampling and data collection methods are described elsewhere. All protocols for data collection in NHANES were approved by the Institutional Review Board at the National Center for Health Statistics, and consent/assent was obtained for all participants, as appropriate, before conducting any study procedures.

Data were collected from individuals aged 2 years or older, who participated in NHANES either in 2009–2010 (n= 9,047) or in 2011–2012 (n =7,939), providing a total sample of 16,986 individuals. Demographic information included the participant's age (categorized as 2 to 5, 6 to 11,12 to 17,18 to 34, 35 to 54, 55 to 74, and older than 75 years); sex; socioeconomic status (low, middle, or high, determined using tertiles of family income to poverty ratio); and self-reported race/ethnicity (non-Hispanic white, non-Hispanic black, or Hispanic). Individuals categorized as Hispanic included individuals who identified as Mexican American or other Hispanic. Individuals who self-identified with a race/ethnicity other than non-Hispanic white, non-Hispanic black, or Hispanic, were excluded from race/ethnicity subgroup analyses but were included in all other analyses. Height was assessed using a stadiometer with a fixed vertical background and an adjustable headpiece. Weight was assessed using a digital scale. Body mass index (BMI; calculated as kg/m^2) and BMI percentile were then calculated for adults and children, respectively, and weight status subgroups (normal weight, overweight, or obese) were determined using standard cutoffs.[9]

Dietary data in NHANES 2009–2010 and 2011–2012 were collected using two 24-hour dietary recalls using the Automated Multiple-Pass Methodology. The first recall is conducted in person by a trained interviewer, while the second recall is conducted 3 to 10 days later by telephone. Data from both days of recall were used to determine the prevalence of LCS consumption, when available. Participants who provided only 1 day of recall (n=1,326 in year 1, n= 890 in year 2) were also included in the analysis, among whom data from only one recall were analyzed. For children younger than 6 years of age, proxy respondents were used to ensure collection of valid and reliable dietary information. Similarly, children aged 6 to 11 years of age completed assisted interviews. Foods and beverages containing LCSs were identified using food descriptions provided in the Food and Nutrient Database for Dietary Studies, version 5.0 and version 11–12, in NHANES 2009–2010 and NHANES 2011–2012, respectively. The Food and Nutrient Database for Dietary Studies database includes all foods and beverages consumed by NHANES participants and is based on detailed food-composition data from the US Department of Agriculture's National Nutrient Database for Standard Reference. Commercially available beverages, foods, and packets containing LCSs were identified using US Department of Agriculture's food code descriptions corresponding to all foods and beverages reported in dietary recalls completed in the 2009–2010 and 2011–2012 cycles.

Food codes containing the terms *diet, dietetic, low-calorie, no sugar added, light, sugar-free, sugar substitute, low-calorie sweetener*, or *no-calorie sweetener* were extracted. Each code was then categorized as an LCS beverage, LCS food, or LCS packet. A total of 4,981 unique food and beverage items were consumed by participants in NHANES 2009–2010. Of these items, 126 contained LCSs, including 57 beverages, 61 foods, and 8 packets. Similarly, 5,192 unique food and beverage items were reported in NHANES 2011–2012. Of these items, 147 contained LCSs, including 74 beverages, 65 foods, and 8 packets.

Importantly, it was not possible to quantify the amount of LCSs in LCS-containing products because manufacturers are not required to provide information regarding the quantity of LCSs added, with the exception of saccharin. Due to the inability to quantify the amount of LCS in foods and beverages, intake (in grams) of LCS-containing products was estimated as

a proportion of an individual's total intake of the specific product category (eg, yogurts, desserts) reported in NHANES. Product categories were grouped using Food and Nutrient Database for Dietary Studies food codes, as described.

Those with implausible energy intake (n= 44), defined as < 475 kcal or > 6,000 kcal were excluded from the analysis. Participants classified as underweight (using the standard cutoffs for adults, BMI <18.5) and using standard BMI percentile cutoffs in children (BMI percentile <5th) were excluded in analyses stratified by weight status due to small sample size (n=103 children, n=207 adults), but were included in all other analyses. Any participant with missing data for any sociodemographic or weight status characteristic was excluded only from the specific subgroup comparison for which data were missing, but were included in all other analyses. In adults, consumption was also compared among individuals with physician-diagnosed diabetes vs those without diagnosed diabetes. Consumption based on the presence of diabetes in children was not assessed due to small sample size (n=13 children with diabetes). The final sample size was n=16,942 (including children [2 to 17 years old]: n=5,844; adults [18 years and older]: n=11,098).

While data from both days of recall were used for prevalence estimates, data from the one, in-person, 24-hour recall (1 day only) were also used to calculate the frequency of LCS consumption (number of times per day), the occasion of LCS consumption (meal vs snack vs consumed alone), and the location of consumption (at home vs away from home). Eating occasions were characterized in accordance with prior studies. The "alone" category referred to consumption of an LCS-containing product separately from other foods or beverages or extended consumption, where an LCS-containing food or beverage was consumed throughout the day, rather than being associated with a particular meal or snack.

The primary outcome was defined as the proportion of US children and adults who reported consuming one or more foods, beverages, or packets containing LCSs during at least one of their two dietary recalls (defined as consumers). Consumption and the context of this consumption was assessed among all participants 2 years and older. Infants and children younger than 2 years of age were excluded due to their unique nutritional needs and feeding practices.

Statistical Analysis

Stata version 13.1 was used with procedures designed to adjust the variances and account for the complex NHANES sampling design used for all analyses. Sample weights were used to generate national level estimates of consumption in the US population. Pooled prevalence estimates of LCS consumption for the 2009–2012 sample (the proportion of all participants in a specific subgroup who were "consumers") were determined using Stata frequency procedures for complex survey design and F tests were used to compare consumption estimates across sociodemographic subgroups. For LCS eating frequency, occasion, and location, X^2 tests were used to examine the differences in consumption patterns across age groups and weight status in unadjusted analyses. Multivariate logistic regression was conducted to assess age-adjusted prevalence and "fully" adjusted prevalence, adjusted for age, sex, race/ethnicity, weight status, income, and presence of diabetes. All P values were

2-sided and $P<0.05$ was considered statistically significant. All values are presented as mean ±standard error of mean.

RESULTS

Percentage of General Population Consuming LCSs (Unadjusted Analyses)

Twenty-five percent (25.1%) of children consumed at least one item containing LCSs on at least 1 of the 2 days of recall, and the prevalence of LCS consumption was highest for LCS beverages (19.0%), followed by LCS foods (7.8%). Very few children consumed LCS packets (0.7%), and only 2.1% of children consumed both LCS beverages and LCS foods. Among adults, 41.4% reported consuming LCSs. Thirty-one percent (30.8%) reported consuming LCS beverages, whereas 10.3% and 14.1% reported LCS foods and LCS packets, respectively. Five percent (5.1%) of adults reported consumption of both LCS foods and LCS beverages, while 7.6% and 2.8% reported consumption of both LCS packets and LCS beverages or both LCS packets and LCS foods, respectively.

Despite the widespread prevalence of LCS consumption, their use was relatively low when evaluated as a proportion of total food and beverage intake (among consumers and nonconsumers). For example, LCS beverage consumption comprises only 1% of the total beverage intake reported in children and 5% of total beverage intake in adults. Similarly, only 1% and 2.5% of all desserts consumed in NHANES 2009–2012 contained LCS, in children and adults, respectively. However, LCS-containing yogurt comprised 25% of total yogurt intake in adults and 10% of total yogurt intake in children.

Subgroup Analyses

The prevalence of LCS use by product category and by sex, income, weight, age, race/ethnicity, and diabetes diagnosis (adults only) is shown in Tables 1 and 2. Females were more likely to consume LCS beverages compared to males, as were individuals with higher family income and higher weight status. In adults, prevalence of LCS intake increased with age, across all product categories. In children, consumption of LCS beverages increased with age, while consumption of LCS foods decreased with age. Consumption of total LCS and LCS packets was highest among school-aged children (6 to 11 years). In children and adults, LCS use was also more common in individuals of non-Hispanic white race/ethnicity, compared to non-Hispanic blacks or Hispanics. Adults with diabetes were more likely to consume LCSs compared to those without diabetes. Prevalence of consumption was similar after adjustment for possible confounders (age, sex, race/ethnicity, weight status, income, and diabetes) in all sociodemographic and weight status subgroups (Table 3, available online at www.andjrnl.org).

Context of LCS Consumption

LCSs w ere typically consumed as part of a meal (64% of adults, 62% of children). Most participants reported consuming LCSs while at home (71% of adults, 72% of children). A higher percentage of at-home LCS use was reported among the youngest children (2 to 5 years old; $P=0.001$) and the oldest adults (75 years of age and older; $P<0.001$).

More than half of LCS consumers reported use of LCS once daily (56% of adults, 80% of children), with few children reporting consumption more than three times per day (4% of children). However, 44% of adults and 20% of children consume LCS more than once daily, and 17% of the adult consumers had a food or beverage with LCSs three or more times daily. Prevalence of consuming LCSs three or more times daily increased with BMI in adults (19.2% obese adults vs 13.4% of normal weight adults; $P<0.001$), but was not statistically significant among children (6.3% obese children vs 2.9% normal weight children; $P=0.17$). Also, frequency of LCS use three or more times daily was highest for beverages (3.1% kids, 9.7% adults), as consumption of LCS foods (0.8% kids, 1.7% adults) or LCS packets (<0.5% children, 6.5% adults) three or more times per day was rare. Consumption occasion (meal vs snack vs alone) and location of LCS consumption did not differ based on weight status.

DISCUSSION

Our results demonstrate that 25% of children and >41% of adults in the United States consumed LCSs in NHANES 2009–2012. In comparison to previously published data from 1999–2000, this represents a 200% increase in consumption in children (8.7% to 25.7%; $P<0.0001$) and a 54% increase among adults (26.9% to 41.5%; $P<0.0001$). These estimates are conservative because the analyses are based on dietary recalls, which may be subject to recall bias. In addition, analyses do not include children younger than 2 years of age, many of whom may not directly consume low-calorie sweeteners, but are exposed to LCSs via breastfeeding (by mothers consuming LCSs during lactation).[,]

The current findings extend previous reports[,] by demonstrating that LCS consumption remains highly prevalent in the United States overall and in all sociodemographic and weight status subgroups. The continued shift toward increasing LCS consumption may be a result of recent obesity-prevention campaigns focusing on reducing intake of added sugars and calories. Other factors may be the increased availability of LCSs in the food supply,[,] due in part to recent developments in blending several LCSs to enhance palatability of LCS-containing products and in com bining LCSs with caloric sugars, and because of the continued reduction in the cost of LCSs. The LCS market is projected to continue to grow at approximately 5% per year through the year 2020. In addition, the increasing prevalence of type 2 diabetes might have also contributed to higher LCS consumption, particularly in older adults, among whom diabetes prevalence is higher than in younger populations. While LCS use has undoubtedly increased over time, it is important to recognize that the current analyses may have better captured LCS exposure by analysis of two 24-hour dietary recalls, whereas only a single dietary recall was available in earlier survey years. The magnitude of increases when compared to findings from earlier reports may be overestimated in the current analysis.

The present study also evaluated the prevalence of LCS consumption by source and context. Consistent with prior studies,[,] consumption of LCS beverages continued to account for the majority of overall LCS consumption in both children and adults, with adults reporting a higher prevalence of LCS beverage consumption, relative to children. Consumption of LCS foods in the current analysis, however, was considerably greater than in previous reports,[,]

with similar prevalence of LCS food use reported in children and adults. This higher consumption of LCSs from food sources is not surprising, as LCSs continue to be incorporated into a variety of grain products, including breads, cereals, and snacks; dairy products, including light yogurt, no-sugar-added ice cream, and flavored milk substitutes; desserts, including reduced-sugar cookies and candies; and, condiments, such as sugar-free jam and/or pancake syrup.[,] The current findings also suggest that the patterns of LCS consumption may reflect those of overall food intake, as approximately 70% of LCSs were consumed in the home, consistent with recent data reporting that more than two-thirds of total calories are consumed within the home.

The com parable prevalence of LCS food consumption in children and adults is also noteworthy. We have previously reported that most parents have negative attitudes toward LCS consumption by their children, yet often do not recognize the presence of LCSs in foods and beverages that they purchase for their families. This study raised the possibility that parents may preferentially select products with nutrient content claims, such as “no sugar added” or “light,” in an effort to provide healthier options to their children, without realizing that these sugar-modified products often contain LCSs.[,] The presence of LCSs in foods commonly consumed by children, such as canned fruit, ice cream, flavored oatmeal, and snack bars, combined with strong marketing and promotion of products deemed to be healthier alternatives, may be driving LCS food intake in children.

Our findings are quite striking in that that more than one-quarter of children and adolescents, and nearly half of the adults in the United States, consume one or more LCS-containing products daily. Despite the widespread prevalence of LCS consumption, most consumers only use LCS-containing products once daily; and total intake of LCS-containing foods and beverages comprised only a small proportion of total intake, and differed significantly by product category. However, this does not imply that the use of LCS is clinically or metabolically insignificant, as even exposures used in low quantities can have important health effects.

Given that a significant proportion of children and adults in the United States consume LCSs, these findings emphasize the need for prospective, long-term, well-controlled studies to determine the chronic health effects, especially in children. While the effects of early life exposure to LCSs on taste preferences, weight management, and chronic disease prevention have not been well-studied in humans, compelling findings in animal models highlight the need to examine their potential health effects in humans.[,] This will subsequently guide currently inconsistent public health recommendations for use or avoidance of LCSs in pediatric populations.

In addition to studying differences in consumption across product categories, age, race/ethnicity, income, weight, and sex differences in the prevalence of LCS consumption in children and adults were also observed. Consistent with prior reports[,] using data from older NHANES survey cycles (1999–2000 through 2007–2008), prevalence of LCS consumption was higher among females, older adults, non-Hispanic white individuals, individuals with obesity, and those with higher socioeconomic status. Similar sociodemographic differences in LCS intake were observed when evaluating LCS intake using household purchase data.

These sociodem ographic differences in consumption of LCSs further emphasize the need to better understand determinants of LCS use and consumer perceptions of LCSs. Specifically, understanding why and how LCSs are used will provide important insights for clinical practice.

Strengths and Limitations

This study is the first to evaluate LCS intake using NHANES 2009–2012 and to explore situational influences on LCS consumption and frequency of LCS intake, and is also strengthened by the use of demographic and dietary data from a large national sample of adults and children. The large sample size enabled meaningful comparisons across socio-demographic subgroups and product categories. Limitations of the study include the inability to calculate the absolute quantities (milligrams) of LCSs consumed as the amount of LCSs in a given food, beverage, or packet is considered proprietary and the lack of specific food codes for subsets of products that often contain LCSs (eg, certain LCS-containing snack foods), which w ere therefore not captured in the analysis. In addition, the self-reported dietary recall data collected during NHANES is subject to recall bias, which may have influenced the results, and the use of two 24-hour dietary recalls may underestim ate usual intake. It was also not possible to evaluate LCS intake in individuals who did not self-identify as non-Hispanic white, non-Hispanic black, or Hispanic, due to substantial heterogeneity between other race/ethnicities, which precluded meaningful comparisons.

CONCLUSIONS

The current analysis confirms that LCS consumption is highly prevalent in children and adults. Our findings highlight the need to understand the health effects of long-term exposure to LCSs and further emphasize the importance of investigating how and why various sources of LCSs are used in order to understand their potential role in promoting or preventing weight gain and chronic disease. This is of particular relevance for registered dietitian nutritionists and clinicians who may recommend LCS use for weight control and diabetes management. Improvements in food labeling and dietary assessment are also needed to more accurately characterize and quantify the use of LCSs in the general population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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THE ART OF DIETETICS

"Reflections of my Cast Iron Moments"—memories of family cast iron artifacts from two generations back are still a part of my food preparation methods. Photo taken by Janice B. Blythe, PhD, RDN, LD.

(The images in "The Art of Dietetics" are past submissions to the *Journal's* Photo Contest and are available for download and educational use at www.andjrnl.org/content/photocontestgallery.)

Table 1.

Prevalence of low-calorie sweetener (LCS) consumption in National Health and Nutrition Examination Survey 20092010 and 2011–2012 among children and adolescents (2 to <1 8 years) by demographic and weight subgroups and by product category (unadjusted)[a]

Characteristic	All LCSs	LCS beverages	LCS foods	LCS packets
	←%±standard error→			
All (n=5,844)	25.1±1.1	19.0±1.0	7.8±0.7	0.7±0.2
Sex				
Male (n=2,998)	23.7±1.3	17.8±1.1	8.3±0.8	0.5±0.2
Female (n=2,846)	26.6±1.3	20.8±1.3*	7.4±0.8	0.8±0.3
Age, y				
2–5 (n=1,695)	21.5±1.6	13.3±1.3	10.5±1.4	0.3±0.1
6–11 (n=2,299)	27.0±1.8**	19.4±1.3***	9.4±1.1	0.9±0.3*
12–17 (n=1,850)	25.7±1.6	22.3±1.6***	4.7±0.7**	0.7±0.3
Socioeconomic status				
Low[bc] (n=2,168)	20.0±1.0	15.4±1.0	6.1±0.6	0.3±0.1
Middle (n=1,774)	25.1±1.6**	18.1±1.5	8.6±1.4*	0.9±0.4
High (n=1,460)	29.9±1.8***	23.3±1.5***	8.8±1.2*	0.7±0.3
Weight				
Normal weight[de] (n=3,776)	23.7±1.1	17.5±0.9	8.2±0.8	0.4±0.2
Overweight (n=863)	25.6±2.3	19.7±2.4	6.7±1.0	0.7±0.3
Obese (n=1,030)	31.0±2.1***	25.9±2.1***	7.0±0.8	1.6±0.6*
Race/ethnicity				
Non-Hispanic white[f] (n=1,632)	30.1±1.8	23.1±1.7	9.2±1.2	0.7±0.3
Non-Hispanic black (n=1,428)	18.9±1.2***	14.2±1.2***	6.0±0.6*	0.4±0.2
Hispanic (n=2,067)	19.7±1.0***	14.0±0.7***	6.6±0.7*	0.8±0.2

[a] *F* tests were used to compare consumption estimates across subgroups.

[b] Defined based on tertiles of poverty-to-income ratio.

[c] n=442 children and adolescents missing socioeconomic status data.

[d]Defined based on standard body mass index percentile cutoffs.

[e]n=72 children and adolescents missing body mass index data.

[f]n=717 children and adolescents who did not self-identify as non-Hispanic white, non-Hispanic black, or Hispanic were excluded from race/ethnicity subgroup analyses.

*$P<0.05$.

**$P<0.01$.

***$P<0.001$.

Table 2.

Prevalence of low-calorie sweetener (LCS) consumption in National Health and Nutrition Examination Survey 2009–2010 and 2011–2012 among adults (≥18 years) by demographic and weight subgroups and by product category (unadjusted)[a]

Characteristic	All LCSs	LCS beverages	LCS foods	LCS packets
	←%±standard error→			
All adults (n=11,098)	41.4±0.8	30.8±0.7	10.3±0.4	14.1±0.8
Sex				
Male (adults) (n=5,465)	36.4±0.9	27.5±0.8	7.4±0.5	11.7±0.7
Female (adults) (n=5,633)	46.2±1.1***	33.8±1.1***	12.9±0.6***	16.3±1.0***
Age, y				
18–34 (n=3,316)	30.1±0.9	24.3±0.9	5.7±0.5	6.4±0.7
35–54 (n=3,632)	42.6±1.5***	32.2±1.7***	9.7±0.7***	13.8±0.8***
55–74 (n=3,060)	50.6±1.7**	35.9±1.5***	14.4±0.9***	21.3±1.5***
>75 (n=1,090)	49.3±1.8***	31.6±2.1**	17.0±1.0***	21.2±1.6***
Socioeconomic status				
Low[bc] (n=2,910)	28.7±1.0	20.6±1.0	7.5±0.7	8.1±0.7
Middle (n=3,410)	37.5±1.3***	27.3±1.1***	9.6±0.6*	12.2±0.9**
High (n=3,819)	49.1±1.1***	37.0±1.0***	12.1±0.7***	17.5±1.1***
Education				
Less than high school[d] (n=2,724)	33.4±1.3	22.4±1.2	8.9±0.8	12.5±0.8
High school (n=2,318)	38.6±1.4*	28.9±1.5**	9.2±1.3	13.4±1.1
Some college (n=3,078)	41.6±1.2***	30.6±1.0***	10.2±0.8	14.7±1.2
College graduate (n=2,399)	50.1±1.6***	38.5±1.6***	12.7±0.7**	16.2±1.3*
Weight				
Normal weight[e,f] (n=3,198)	33.3±1.3	24.0±1.2	8.4±0.7	9.6±1.0
Overweight (n=3,544)	41.8±1.3***	30.1±1.3**	10.1±0.5	15.1±1.0***
Obese (n=4,023)	49.1±1.5***	38.0±1.4***	12.2±0.7**	17.3±1.1***
Race/ethnicity				
Non-Hispanic white (n=4,776)	46.7±0.9	35.4±1.1	11.9±0.5	15.6±1.0

Characteristic	All LCSs	LCS beverages	LCS foods	LCS packets
Non-Hispanic black (n=2,452)	28.4±1.0***	20.5±1.1***	7.7±0.4***	10.1±0.9***
Hispanic (n=2,752)[g]	32.1±0.9***	21.7±1.1***	6.5±0.4***	12.3±0.7*
Diabetes				
Yes[h] (n=1,283)	67.4±1.8	50.0±1.9	20.6±1.6	31.1±1.9
No (n=9,809)	39.0±0.8***	29.0±0.7***	9.3±0.4***	12.5±0.7***

[a] *F* tests were used to compare consumption estimates across subgroups.

[b] Defined based on tertiles of poverty-to-income ratio.

[c] n=959 adults missing socioeconomic status data.

[d] n=579 missing education data.

[e] Defined based on standard body mass index cutoffs.

[f] n=126 adults missing body mass index data.

[g] n=1,118 adults who did not self-identify as non-Hispanic white, non-Hispanic black, or Hispanic were excluded from race/ethnicity subgroup analyses.

[h] n=6 adults missing diabetes data.

* $P<0.05$.

** $P<0.01$.

*** $P<0.001$.