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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.

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.

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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.[1,2] In addition, stevioside and rebaudioside A, extracts of the *Stevia rebaudiana* Bertoni plant are used and regulated as dietary supplements.[2]

Although LCSs were once believed to be metabolically inert, more recently their use has become controversial.[3,4] Some studies have suggested a beneficial effect on weight loss,[5-7] while others indicate that obesity risk increases with LCS use.[8,9] 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 management and chronic

disease, it is important to determine 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.[10-15] Mattes and Popkin[10] first documented increasing LCS consumption in the US population between 1989 and 2004. 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.[11] This analysis also demonstrated that consumption of commercially available beverages containing LCSs was driving the overall increase in LCS use. Recently, Drewnowski and Rehm[12] examined sociodemographic correlates of LCS use from 1999 to 2008 and showed that LCS intake was highest among individuals with higher socioeconomic status, non-Hispanic white individuals, females, and overweight and obese individuals.[12] 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.[13]

Piernas and colleagues[14] and Ng and colleagues[15] have also examined intake of LCS-containing foods and beverages using NHANES 2003-2010[14] and household purchase data from 2000-2010.[14,15] Another study by the same group assessed consumption of LCS-containing foods in 2003 to 2010 in relation to diet quality.[16] 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, cross-sectional study of the US population, with data released in 2-year cycles. NHANES sampling and data collection methods are described elsewhere.[17] 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.[18,19]

Dietary data in NHANES 2009-2010 and 2011-2012 were collected using two 24-hour dietary recalls using the Automated Multiple-Pass Methodology.[20] 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.[17] Foods and beverages containing LCSs were identified using food descriptions provided in the Food and Nutrient Database for Dietary Studies, version 5.0[21] and version 11-12,[22] 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.[23] 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[20] were excluded from the analysis. Participants classified as underweight (using the standard cutoffs for adults,[19] BMI <18.5) and using standard BMI percentile cutoffs in children[18] (BMI percentile <5th) were