

# Reported Consumption of Low-Calorie Sweetener in Foods, Beverages, and Food and Beverage Additions by US Adults: NHANES 2007–2012

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## Abstract

**Background:** Low-calorie sweeteners (LCSs), artificial sweeteners, or high-intensity sweeteners are incorporated into foods, beverages, and food and beverage additions (FBAs). Many prior studies have focused on LCS beverage consumption, but not included LCS consumption from foods or FBAs.

**Objectives:** We aimed to describe the prevalence of LCS consumption by US adults, and to examine the relation between intake of products containing LCSs and macronutrients.

**Methods:** Two nonconsecutive 24-h dietary recalls from NHANES 2007–2012 and the National Cancer Institute usual intake method were used to estimate prevalence of LCS intake from foods, beverages, and FBAs, and macronutrients among US adults aged  $\geq 19$  y ( $n = 14,098$ , weighted  $n = 218,391,752$ ) in a cross-sectional study. The prevalence of LCS consumption from reported foods, beverages, and FBAs among US adults was examined by sociodemographic characteristics and body mass index (BMI). Logistic regression estimated ORs and 95% CIs for associations between sociodemographic characteristics and LCS use (overall and in foods, beverages, and FBAs).

**Results:** Among adults, 47.8% reported intake of  $\geq 1$  food, beverage, or FBA containing LCSs over 2 d. Intake was higher among: women non-Hispanic whites, college graduates or higher, and those with higher income and obese BMIs ( $P < 0.001$ ). Intake of beverages containing LCSs was higher for ages 51–70 y than 19–30 y and those with overweight and obese BMIs ( $P < 0.001$ ) than for normal-weight individuals. Calories, carbohydrate, and sugar intake were lower and fiber was higher in LCS-consumers than in nonconsumers. Specifically, calories from beverages were lower in those who reported LCS intake.

**Conclusions:** Individuals reporting LCS consumption demonstrated lower total energy intake than did individuals without LCS intake. Although the main source of LCSs in the US adult diet was beverages (31.9%), we found that FBAs also present a significant contribution (25.2%), surpassing food (9.3%). This enables targeted understanding of national consumption of these products as well as dietary education and intervention opportunities. *Curr Dev Nutr* 2018;2:nzy054.

## Introduction

Low-calorie sweeteners (LCSs), artificial sweeteners, or high-intensity sweeteners are incorporated into foods, beverages, and food and beverage additions (FBAs) as an alternative to sugars or nutritive sweeteners (NSs). Compared with NSs, LCSs can result in overall dietary calorie reduction and have been successfully used in weight management (1, 2). It also has been suggested that LCSs can assist with weight loss and management of diabetes (3–8). Lower overall total caloric intake has been reported among adults with normal weight, but not overweight or obese, BMIs



**Keywords:** NHANES, low-calorie sweetener, artificial sweetener, high-intensity sweetener, adults, macronutrient, dietary, nutritive sweetener

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Abbreviations used: FBA, food and beverage addition; FNDDS, Food and Nutrient Database for Dietary Studies; HEI, Healthy Eating Index; LCS, low-calorie sweetener; NCI, National Cancer Institute; NS, nutritive sweetener; SES, socioeconomic status; WWIEA, What We Eat in America.

consuming LCSs (9). In addition, some studies have reported a relation between consumption of LCS-containing beverages and obesity risk (7, 8), whereas a recent study found dietary intake and glycemic response to be equal or better after consumption of beverages containing LCSs compared with water (10). However, controversy still exists with regard to LCS consumption and health effects including weight management (11).

The question of whether LCSs are directly beneficial for weight loss also has been examined in rodent models by multiple authors. Swithers and Davidson (12) reported weight gain and increased adiposity in rats after intake of yogurt with added saccharin compared with added glucose, and consumption of more calories by rats that consumed saccharin-sweetened yogurt (12). Rodents on a high energy, fat, and sugar diet (HE or Westernized diet) fed saccharin compared with glucose yogurt supplements experienced increased adiposity, weight gain, and energy intake (13). However, a recent Australian study replicating Swithers and Davidson's 2008 work found the opposite: greater weight gain and fat pad mass for rats fed glucose-sweetened compared with saccharin-sweetened yogurt (14).

LCS consumption has been associated with healthier lifestyle choices, such as increased physical activity, greater fruit and vegetable intake, and higher overall Healthy Eating Index (HEI) scores (15); however, recent reports suggest LCS intake is increasing in the United States in parallel with rates of overweight and obesity (16, 17). Although diet quality has been assessed in relation to LCS intake through the use of HEI-2010 and macronutrient intake assessed in consumers of LCS-containing beverages, only 1 study has assessed macronutrient intake in consumers of foods, beverages, and packets containing LCSs (18). Some studies have assessed LCS intake from foods and beverages or beverages alone; however, none have fully incorporated the concept of FBAs (2, 19, 20). Examining LCS use in the context of the total diet (foods, beverages, FBAs) is important to better provide targeted food intake guidance.

In the current study our purpose was to assess the prevalence of LCS intake in the total diet of foods, beverages, and FBAs among US adults through the use of 2 nonconsecutive 24-h dietary recalls from the NHANES 2007–2012 and the National Cancer Institute (NCI) usual intake method (21–23). We also examined the relation among overall, no/low, and high intake of LCSs and NSs in items consumed as well as calorie and dietary macronutrient intake levels among individuals with and without reported intake of LCS- and NS-containing items.

## Methods

### Study design and population

Sociodemographic and dietary data were obtained from the 3 most recent NHANES cycles (2007–2008, 2009–2010, 2011–2012) for this cross-sectional study. The NHANES survey and physical exam are administered in 2-y cycles by the National Center for Health Statistics (NCHS) to a national sample of US adults and children (24). Each NHANES continuous cycle used a complex, multistage probability sample to obtain national-level data with oversampling of certain population subgroups (25). Two nonconsecutive 24-h dietary recalls were collected by trained dietary interviewers for each included NHANES cycle, of which the first was in-person and the second followed 3–10 d later by phone. The USDA Food and Nutrient Database

for Dietary Studies (FNDDS) was used to code all food and beverage items reported consumed in the NHANES dietary interview component (What We Eat in America, WWEIA) and to obtain nutrient content (26). The NCI usual intake method was used to estimate macronutrient intake in US adults (defined as  $\geq 19$  y old) who did and did not use LCSs (23).

The pooled NHANES 2007–2012 data included 30,442 individuals, of which 18,191 were adults aged  $\geq 19$  y. After limiting to adults with data considered reliable by the NCHS, excluding pregnant and lactating women ( $n = 477$ ) and those without 2 complete nonconsecutive 24-h dietary recalls ( $n = 3616$ ), the analytic sample was 14,098 US adults (men,  $n = 6925$ ; women,  $n = 7173$ ; weighted  $n = 218,391,752$ ). Those with underweight BMI ( $n = 237$ ) or missing BMIs ( $n = 173$ ) also were excluded.

### Characteristics

Age was categorized into the following age groups: 19–30, 31–50, 51–70, and  $\geq 71$  y. Race/ethnicity was classified as: non-Hispanic white, non-Hispanic black, Hispanic, or other which included non-Hispanic persons reporting multiple races. Education was categorized as: high school graduate/General Educational Development or lower, completing some college or an associate degree, or college graduate or higher. Poverty income ratio was defined as: below the poverty line, at/above the poverty line, or above 3 times the poverty line. BMI ( $\text{kg}/\text{m}^2$ ) was classified as: underweight ( $< 18.5$ ), normal weight (18.5–24.9), overweight (25–29.9), or obese ( $\geq 30$ ).

### Food and beverage items, including FBAs, and sweeteners

Those items that were primarily consumed on their own were classed as foods or beverages; however, items not typically used on their own but rather added to or consumed with a food or beverage item were termed “FBAs” (e.g., creamer, sugar/packaged LCSs, ketchup, butter, and salad dressing). Food, beverage, and FBA items were coded as containing LCSs if the USDA item descriptions such as “with low/no-calorie sweetener”, “sugar-free”, or “dietetic/low sugar” were used; or if review of the online ingredients list for processed foods or the recipes for homemade ethnic foods indicated that the items contained LCSs or NSs. The USDA listing of inclusion of sugar and related ingredients was also consulted (<https://fnic.nal.usda.gov/food-composition/nutritive-and-nonnutritive-sweetener-resources>). The adjudication process for coding of ingested items was described previously (27). If an individual reported intake of food, beverage, or FBA containing LCSs over the 2-d period (two 24-h recalls: 1 in person and 1 by telephone) they were considered positive for LCS intake whereas individuals who did not report LCS intake were considered negative for intake. In addition, individuals were dichotomized based on LCS intake specific to food, beverages, or FBAs. We were also interested in the number of times a person used NSs and total sugars consumed based on reported foods over the 2 d of recall. Based on an initial distribution, we identified NS use  $\leq 6$  times over 2 d, which corresponded to 21.5% of the population, as low frequency of NS use and high frequency of NS use was defined as NSs  $> 6$  times over 2 d. The following LCS and NS intake groups were used: no or low NSs and no LCSs (10.6%), no or low NSs along with LCSs (10.9%), high NSs and no LCSs (41.6%), or high NSs along with LCSs (36.9%).

## Statistical analysis

Demographic characteristics, socioeconomic status (SES) factors, and BMI were compared by food, beverage, and FBA items containing LCSs with the use of descriptive statistics, such as Wald chi-square tests. All analyses accounted for the clustered sampling design and oversampling, and adjustments were made for differential noncoverage and nonresponse adjusted by the 3 continuous NHANES cycles (25, 28). We used multivariate logistic regression to evaluate the associations between demographic characteristics and SES factors, with LCS use (overall and separately in foods, beverages, and FBAs) being the outcome of interest through calculation of ORs and 95% CIs. Models adjusted for covariates including: NHANES cycle, sex, race/ethnicity, age, education, poverty income ratio, and BMI category.

Usual dietary intake levels of nutrients over two 24-h recalls were examined by LCS intake with adjustment for age, race, sex, day, and weekend day through the use of the NCI usual intake estimation methodology (21–23). Usual dietary intake levels of nutrients were also assessed by NS/LCS use and BMI category after adjustment for age, race, sex, day, weekend day, and other NS/LCS intake categories.

All analyses were conducted via SAS, version 9.3 and its complex survey-specific procedures (SAS Institute; Cary, NC). Institutional Review Board approval was not required by the Medical University of South Carolina because the study involved a secondary data analysis and was not deemed to be human subjects research.

## Results

The national prevalence of LCS intake overall and in foods, beverages, and FBAs among US adults over 2 d is presented in **Table 1**. Approximately 48% of adults reported consuming foods (9.3%), beverages (31.9%), or FBAs (25.2%) containing LCSs. Over a 2-d period, 3.0%  $\pm$  0.2% of adults reported LCS intake in foods only; 17.5%  $\pm$  0.6% in beverages only; and 11.3%  $\pm$  0.4% in FBAs only (data not shown). Most individual respondents reported consuming LCSs from multiple dietary sources. Hence, the 25.2% who reported LCS intake in FBAs includes adults who reported LCSs in FBAs only (11.3%); LCSs in beverages and FBAs (9.7%); LCSs in foods and FBAs (1.6%); and LCSs in food, beverages, and FBAs (2.6%) (data not shown). Women, non-Hispanic whites, college graduates or higher, those aged  $\geq$ 71 y, and those of higher income were more likely to consume food containing LCSs ( $P < 0.001$ ) than the respective comparison groups. Individuals of these groups (except those aged  $\geq$ 71 y) as well as obese individuals (BMI  $>$  30) and those aged 51–70 y were also more likely to consume beverages or FBAs containing LCSs than the respective comparison groups ( $P < 0.001$ ).

**Table 2** displays ORs and 95% CIs predicting LCS intake across 2 d overall and in foods, beverages, and FBAs among US adults. The odds of LCS intake overall and in food and FBAs increased with age. More specifically, the odds of LCS use in FBAs were 1.37 (95% CI: 1.10, 1.71) for 31- to 50-y-olds, more than 2-fold for 51- to 70-y-olds (OR = 2.20, 95% CI: 1.73, 2.79), and 3-fold for  $\geq$ 71-y-olds (OR = 3.06, 95% CI: 2.36, 3.96) compared with 19- to 30-y-olds. LCS intake in foods had higher odds among persons of all age groups than 19- to 30-y-olds, whereas LCS intake in beverages had higher odds among 51- to 70-y-olds. The odds of LCS intake overall and in foods and beverages were

elevated among those with college education or higher compared with high school education or lower. Differences in LCS intake were also observed by BMI category with higher odds overall and in beverages and FBAs among those classed as overweight and obese BMIs compared with normal weight.

The nutrient intake (mean  $\pm$  SE) of individuals by reported LCS intake is shown in **Table 3** with adjustment for age, race, sex, day, and weekend day. Compared with nonconsumers, mean calorie (2299 compared with 2122 kcal), carbohydrates (286.5 compared with 253.2 g), and total sugars (135.7 compared with 110.9 g) were significantly lower for LCS consumers ( $P < 0.001$ ). Fiber intake was significantly higher for LCS consumers than nonconsumers (17.7 compared with 16.4 g;  $P < 0.001$ ).

The national prevalence (percentage  $\pm$  SE) of NS use is reported in **Table 4**. Only 0.1% of the population reported no NS intake over the 2-d period; whereas 21.5% reported intake of foods, beverages, or FBAs containing NSs  $\leq$  6 times. As expected, mean total sugars consumed increased from 27.5 g among individuals whose diet did not include NSs to 158.8 g among individuals who used NSs  $\geq$  11 times over the 2-d period. The prevalence of LCS use ranged from 15.6% among individuals without reported dietary NS intake to 54.4% among those who used NSs 4 times over the 2-d period. Based on the distribution of the reported NS intake times over 2 d, 21.5% of adults were categorized as having no or low frequency of NS use ( $\leq$  6 times) and 78.5% of individuals were categorized as having high frequency of NS use ( $>$  6 times).

**Figure 1** presents mean  $\pm$  SE macronutrient intake of energy for US adults by LCS and NS intake categories adjusted for age, race, sex, day, and weekend day. Among individuals consuming NSs  $\leq$  6 times over the 2 d, mean intake of energy (1797 compared with 1699 kcal) was significantly lower for LCS consumers than nonconsumers ( $P < 0.05$ ), as were carbohydrates (211.2 compared with 188.6 g) and total sugars (80.8 compared with 72.2 g) (data not shown). Among NS consumers who used NSs  $\leq$  6 times over the 2 d, dietary fiber was significantly higher than among nonconsumers of LCSs (14.8 compared with 14.2 g;  $P < 0.05$ ) (data not shown). Results were similar in those reporting NS use  $\geq$  6 times over the 2 d with total fat also differing significantly between the 2 groups.

The nutrient intake (mean  $\pm$  SE) of individuals by reported LCS intake was also examined by BMI category with adjustment for age, race, sex, day, and weekend day (**Table 5**). The energy, carbohydrate, and total sugar intake among overweight or obese (BMI) US adults who reported use of LCS-containing foods, beverages, or FBAs were significantly lower compared with those without LCS intake, whereas fiber was significantly higher ( $P < 0.05$ ). Moreover, when examining energy from food, beverages, and FBAs in those with reported LCS use, reduced energy was largely the result of reduced calories from beverages in individuals with either an overweight or obese BMI, and from both food and beverages in those with a normal BMI.

## Discussion

Our study examined characteristics associated with the prevalence of LCS intake in adults from 2007–2012. Over a 2-d period, 48% of US adults reported LCS intake in foods, beverages, or FBAs, which is higher than past reports based on earlier NHANES cycles involving 1-d (16, 29) or 2-d (18) recall. The majority of LCS intake was in beverages

**TABLE 1** Percentages  $\pm$  SEs of NHANES participants reporting LCS intake overall and from foods, beverages, and FBAs by sociodemographic characteristics of the US adult population based on two 24-h dietary recalls<sup>1</sup>

Characteristic	Sample, n	Estimate of total US		LCS intake in food	LCS intake in beverages	LCS intake in FBAs
		population, n	Any LCS intake			
Overall mean	14,098	218,391,752	47.8 $\pm$ 0.7	9.3 $\pm$ 0.4	31.9 $\pm$ 0.7	25.2 $\pm$ 0.7
NHANES cycle						
2007–2008	4696	71,297,655	46.9 $\pm$ 1.0	8.7 $\pm$ 0.6	31.9 $\pm$ 1.3†	25.9 $\pm$ 1.1
2009–2010	5055	72,226,896	48.7 $\pm$ 1.2	10.1 $\pm$ 0.7	34.0 $\pm$ 0.7	25.2 $\pm$ 1.4
2011–2012	4347	74,867,201	47.7 $\pm$ 1.5	9.1 $\pm$ 0.6	29.9 $\pm$ 1.6	24.5 $\pm$ 1.3
Sex						
Male	6925	106,074,482	42.9 $\pm$ 1.0*	7.0 $\pm$ 0.6*	28.8 $\pm$ 0.9*	21.4 $\pm$ 0.7*
Female	7173	112,317,269	52.4 $\pm$ 0.9	11.6 $\pm$ 0.5	34.8 $\pm$ 1.0	28.8 $\pm$ 1.0
Race/ethnicity						
NH white	6493	149,994,144	52.9 $\pm$ 0.8*	11.0 $\pm$ 0.5*	35.8 $\pm$ 1.0*	27.9 $\pm$ 0.9*
NH black	3045	25,268,838	34.4 $\pm$ 1.3	6.2 $\pm$ 0.6	21.6 $\pm$ 1.1	18.9 $\pm$ 0.9
Hispanic	3536	29,792,822	38.7 $\pm$ 1.3	5.3 $\pm$ 0.4	24.3 $\pm$ 1.3	20.5 $\pm$ 1.0
Other	1054	1,333,594	36.3 $\pm$ 2.7	5.9 $\pm$ 1.1	24.7 $\pm$ 2.4	17.4 $\pm$ 1.9
Age category, y						
19–30	2672	4,619,435	35.0 $\pm$ 1.6*	4.6 $\pm$ 0.5*	24.4 $\pm$ 1.4*	14.1 $\pm$ 1.3*
31–50	4605	81,004,552	45.5 $\pm$ 1.3	8.3 $\pm$ 0.7	32.0 $\pm$ 1.3	22.0 $\pm$ 1.0
51–70	4554	6,772,176	56.0 $\pm$ 1.4	12.2 $\pm$ 0.8	36.9 $\pm$ 1.5	32.4 $\pm$ 1.1
71–80	2267	23,471,084	57.3 $\pm$ 1.4	14.0 $\pm$ 0.9	32.0 $\pm$ 1.3	37.2 $\pm$ 1.6
Education						
High school grad/GED or lower	6765	86,882,020	42.7 $\pm$ 0.9*	7.5 $\pm$ 0.6*	28.7 $\pm$ 1.1*	22.3 $\pm$ 0.9†
Some college or associates degree	3883	65,220,752	46.3 $\pm$ 1.2	8.5 $\pm$ 0.7	30.0 $\pm$ 1.1	25.5 $\pm$ 1.0
College graduate or higher	3062	62,112,675	58.0 $\pm$ 1.6	13.2 $\pm$ 0.8	39.3 $\pm$ 1.9	29.9 $\pm$ 1.5
Poverty income ratio						
Below poverty line	5964	68,310,309	37.7 $\pm$ 1.1*	5.9 $\pm$ 0.4*	24.5 $\pm$ 0.9*	19.1 $\pm$ 0.8*
At/above poverty line	3707	6,106,448	48.1 $\pm$ 1.5	8.7 $\pm$ 0.6	32.4 $\pm$ 1.3	25.1 $\pm$ 1.0
Above 3 $\times$ poverty line	3270	74,646,259	57.8 $\pm$ 1.1	12.9 $\pm$ 0.8	39.2 $\pm$ 1.4	31.5 $\pm$ 1.2
BMI category <sup>2</sup>						
Underweight	237	3,442,943	27.1 $\pm$ 4.2*	7.6 $\pm$ 2.3	10.3 $\pm$ 3.1*	15.1 $\pm$ 2.9*
Normal weight	3828	64,638,135	39.5 $\pm$ 1.6	8.5 $\pm$ 0.6	24.1 $\pm$ 1.2	20.0 $\pm$ 1.3
Overweight	4636	71,655,950	49.3 $\pm$ 1.1	9.4 $\pm$ 0.6	32.5 $\pm$ 1.3	26.0 $\pm$ 0.9
Obese	5224	76,608,215	54.4 $\pm$ 1.3	10.0 $\pm$ 0.6	39.2 $\pm$ 1.3	29.3 $\pm$ 1.0

<sup>1</sup>Values are %  $\pm$  SEs unless otherwise indicated. \*Statistically significant differences between categories within a column at  $P < 0.001$  (i.e., for Any LCS intake the prevalence is different in men and women). FBA, food and beverage addition; GED, General Educational Development test; LCS, low-calorie sweetener; NH, non-Hispanic.

<sup>2</sup>BMI (kg/m<sup>2</sup>) was defined as: underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), or obese ( $\geq$ 30), and was unavailable for 173 individuals.

(31.9%); however, an additional 15.9% of individuals reported LCS intake in foods and/or FBAs who did not report consumption of LCSs in beverages. Consistent with previous research, there were higher odds of LCS intake among non-Hispanic whites, women, elderly (aged  $\geq$ 71 y), and persons of higher SES (29), although we also observed higher odds of LCS intake among individuals with obese BMIs. LCS intake in FBAs and food appeared to increase with age, whereas intake in beverages was highest among 51–70-y-olds.

Nutrient intake was also examined and calorie, carbohydrate, and sugar intake were found to be significantly lower (and fiber higher) in individuals who reported intake of foods, beverages, and FBAs containing LCSs than in individuals who did not report LCS intake. Our findings of fewer kilocalories per gram among individuals who report LCS intake are consistent with previous studies (1) and hold when stratified by level of NS use. Because obesity is a potential confounder of the relation between LCSs and nutrient level, LCS intake was further stratified by BMI category as consistent with the literature (16). Differences in nutrient levels were observed within different BMI categories. Compared with adults with reported LCS intake, energy, carbohydrate, and sugar levels were

elevated in adults without reported LCS intake regardless of BMI category.

### Previous studies

LCS intake in beverages has been assessed by previous studies, but few have assessed intake in food and/or FBAs (2, 9, 16, 18, 30). Sylvetsky et al. (18) examined LCS intake from foods, beverages, and packets over two 24-h dietary recalls with the use of USDA FNDDS food descriptions. They also assessed LCS intake through meals and snacks and when consumed alone (separate from foods, beverages, meals, or snacks) (18). Meal occasions were defined according to past studies (31); FBAs such as pickle relish, mayonnaise, or ketchup were considered as foods in the analysis (18) (AC Sylvetsky, George Washington University, BP Marriott, personal communication, 2017).

Piernas et al. (2) found lower diet quality among LCS-beverage consumers than nonconsumers. However, Drewnowski and Rehm (15) reported higher dietary quality scores (via the HEI-2005) among consumers of LCS beverages and foods. In addition to providing fewer kilocalories per gram than caloric sweeteners, LCS use has been associated with healthier lifestyle choices, such as increased

**TABLE 2** ORs and 95% CIs predicting LCS intake overall and in foods, beverages, and FBAs by US adults over 2 d<sup>1</sup>

Characteristic	OR (95% CI)			
	Any LCS intake	LCS intake in foods	LCS intake in beverages	LCS intake in FBAs
Sex				
Female	1.00	1.00	1.00	1.00
Male	0.63 (0.56, 0.71)	0.54 (0.42, 0.69)	0.70 (0.62, 0.80)	0.66 (0.59, 0.73)
NHANES cycle				
2007–2008	1.00	1.00	1.00	1.00
2009–2010	1.08 (0.96, 1.22)	1.20 (0.98, 1.48)	1.10 (0.95, 1.27)	0.96 (0.80, 1.15)
2011–2012	1.05 (0.91, 1.22)	1.09 (0.90, 1.32)	0.90 (0.73, 1.10)	0.94 (0.79, 1.13)
Race/ethnicity				
NH white	1.00	1.00	1.00	1.00
NH black	0.52 (0.45, 0.60)	0.68 (0.54, 0.87)	0.51 (0.42, 0.61)	0.70 (0.59, 0.82)
Hispanic	0.78 (0.66, 0.91)	0.70 (0.59, 0.83)	0.68 (0.56, 0.83)	0.98 (0.82, 1.17)
Other	0.62 (0.49, 0.78)	0.57 (0.39, 0.83)	0.74 (0.56, 0.97)	0.69 (0.50, 0.96)
Age category, y				
19–30	1.00	1.00	1.00	1.00
31–50	1.15 (0.96, 1.37)	1.39 (1.03, 1.89)	1.10 (0.91, 1.32)	1.37 (1.10, 1.71)
51–70	1.66 (1.39, 1.99)	2.06 (1.52, 2.81)	1.27 (1.03, 1.58)	2.20 (1.73, 2.79)
≥71	1.98 (1.59, 2.45)	2.74 (2.04, 3.69)	1.09 (0.86, 1.38)	3.06 (2.36, 3.96)
Education				
High school grad/GED or lower	1.00	1.00	1.00	1.00
Some college or associates degree	1.03 (0.89, 1.19)	0.99 (0.73, 1.33)	0.93 (0.78, 1.11)	1.15 (0.93, 1.41)
College graduate or higher	1.64 (1.40, 1.92)	1.64 (1.24, 2.19)	1.39 (1.14, 1.69)	1.36 (1.07, 1.73)
Poverty income ratio				
Below poverty line	1.00	1.00	1.00	1.00
At/above poverty line	1.30 (1.13, 1.50)	1.30 (1.05, 1.60)	1.31 (1.12, 1.53)	1.24 (1.06, 1.46)
Above 3× poverty line	1.71 (1.52, 1.92)	1.76 (1.32, 2.36)	1.56 (1.38, 1.76)	1.63 (1.34, 1.99)
BMI category <sup>2</sup>				
Underweight	0.69 (0.41, 1.17)	1.07 (0.42, 2.74)	0.38 (0.17, 0.85)	0.89 (0.54, 1.47)
Normal weight	1.00	1.00	1.00	1.00
Overweight	1.54 (1.28, 1.84)	1.20 (0.94, 1.54)	1.57 (1.29, 1.92)	1.40 (1.18, 1.67)
Obese	2.13 (1.81, 2.51)	1.30 (1.08, 1.57)	2.35 (1.99, 2.78)	1.70 (1.46, 1.97)

<sup>1</sup>Adjusted for column covariates: sex, race/ethnicity, age, education, poverty income ratio, and BMI category. Sample: 12,440 people with completed data across all covariates modeled. Models compared LCS intake overall and in food, beverages, and FBAs among characteristics by columns. FBA, food and beverage addition; GED, General Educational Development test; LCS, low-calorie sweetener; NH, non-Hispanic.

<sup>2</sup>BMI (kg/m<sup>2</sup>) defined as: underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), or obese (≥30).

fruit/vegetable intake (2) and physical activity levels (15). Although a large proportion of LCS intake results from LCS-containing beverages, this pertains to only a single behavior. The addition of foods and separately FBAs to this analysis gives insight into eating as well as drinking behaviors, enabling identification of dietary behaviors as targets for intervention.

From 1999 to 2008, the prevalence of LCS intake in the United States increased with ≥50-y-olds and women experiencing the greatest increase, although an increase was not observed over NHANES cycles, 2005–2008 (16, 29). Intake of beverages containing LCSs also increased among women during this period (29). However, these studies involved only a single dietary recall which may underestimate the true prevalence

**TABLE 3** Mean ± SE usual dietary intake levels of nutrients by US adults by LCS category of consumption over 2 d<sup>1</sup>

Nutrient	No LCS intake (52.2%)	LCS intake (47.8%)	P value <sup>2</sup>
Energy, kcal	2299 ± 44	2122 ± 69	<0.001*
From food	1668 ± 32.4	1629 ± 59.0	0.4468
From beverages	515 ± 12.1	339.4 ± 7.6	<0.001*
From food and beverage additions	158 ± 7.4	154 ± 8.8	0.7266
Energy density, kcal/g	0.68 ± 0.0	0.60 ± 0.0	<0.001*
Carbohydrate, g	286.5 ± 3.3	253.2 ± 5.8	<0.001*
Protein, g	81.7 ± 2.2	81.8 ± 2.7	0.6497
Total fat, g	84.7 ± 1.9	81.2 ± 3.5	0.0776
Total sugars, g	135.7 ± 2.1	110.9 ± 1.9	<0.001*
Dietary fiber, g	16.4 ± 0.4	17.7 ± 0.5	<0.001*

<sup>1</sup>Adjusted for: age, race, sex, day, and weekend day. Sample: 14,098 people representative of 218,391,752 adults nationally. \*Statistically significant at  $P < 0.001$ . LCS, low-calorie sweetener.

<sup>2</sup>P values compared usual dietary intake levels of nutrients by LCS use.

**TABLE 4** NS intake in food, beverage, and FBA by US adults over 2 d: frequency, mean  $\pm$  SE grams of total sugars consumed by NS count, and prevalence of any LCS intake by NS count<sup>1</sup>

NS category	NS intake over 2 d, n	Distribution, % $\pm$ SE	Total sugars, mean $\pm$ SE, g	Any LCS intake, % yes $\pm$ SE
No or low NS intake <sup>2</sup> 21.5% $\pm$ 0.58%	0	0.1 $\pm$ 0.1	27.5 $\pm$ 4.4	15.6 $\pm$ 8.4
	1	0.5 $\pm$ 0.1	44.9 $\pm$ 5.3	33.8 $\pm$ 6.0
	2	1.3 $\pm$ 0.1	54.3 $\pm$ 5.2	39.3 $\pm$ 5.8
	3	2.7 $\pm$ 0.2	61.6 $\pm$ 2.6	50.7 $\pm$ 3.9
	4	4.0 $\pm$ 0.3	68.3 $\pm$ 2.7	54.4 $\pm$ 3.2
	5	5.7 $\pm$ 0.3	81.7 $\pm$ 2.3	51.7 $\pm$ 2.5
High NS intake <sup>2</sup> 78.5% $\pm$ 0.58%	6	7.1 $\pm$ 0.3	88.1 $\pm$ 2.3	51.7 $\pm$ 2.5
	7	8.1 $\pm$ 0.4	99.0 $\pm$ 2.8	44.4 $\pm$ 2.0
	8	9.2 $\pm$ 0.3	109.9 $\pm$ 2.0	51.1 $\pm$ 2.1
	9	8.9 $\pm$ 0.3	113.7 $\pm$ 2.7	47.3 $\pm$ 2.6
	10	9.9 $\pm$ 0.4	122.4 $\pm$ 3.2	50.0 $\pm$ 2.0
	$\geq 11$	42.4 $\pm$ 0.7	158.8 $\pm$ 2.3	45.9 $\pm$ 0.8

<sup>1</sup>Adjusted for: day and weekend day. Sample: 14,098 people representative of 218,391,752 adults nationally. FBA, food and beverage addition; LCS, low-calorie sweetener; NS, nutritive sweetener.

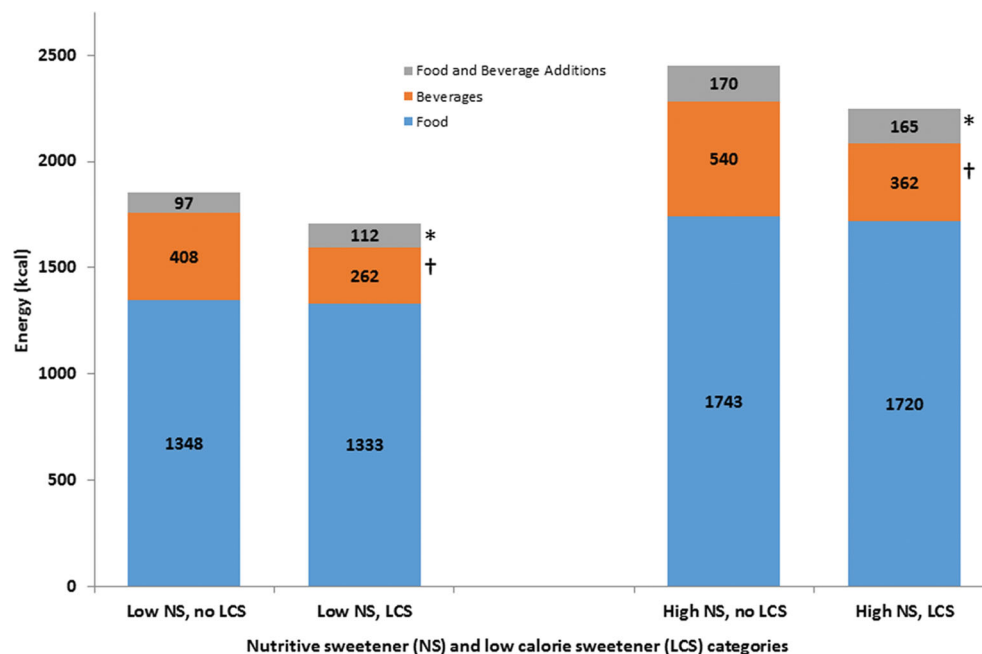
<sup>2</sup>No or low-frequency NS use was defined as  $\leq 6$  times over a 2-d period and high-frequency NS use was defined as  $>6$  times over 2 d.

of LCS use. Further, recent studies utilizing NHANES data have not evaluated macronutrient intake in relation to LCSs (16, 29).

### Strengths and limitations

Our results were based on dietary information from two 24-h recalls, and are subject to limitations. For the 24-h recall data available from NHANES, underreporting portion size of all food and drink items has been cited as an issue and may affect nutrient levels, which may underestimate overall LCS and NS intake among US adults (32).

Although differential misclassification may occur owing to misreporting by BMI category, after further stratifying LCS intake by BMI category, differences in nutrient levels including total energy remained. Moreover, capturing use in food and FBAs reduces misclassification when categorizing individuals based on reported LCS intake. Our use of dietary data from 3 continuous NHANES cycles (2007–2012), and the matching versions of USDA's FNDDS 5.0 (26), does not reflect current (2018 LCS) intake or market availability in food, beverage, and FBA items. Further, our ability to identify the specific type of



**FIGURE 1** Usual dietary intake levels of energy from foods, beverages, and food and beverage additions by LCS category over 2 d stratified by NS category. Low NS was defined as using NS  $\leq 6$  times over a 2-d period and high NS was defined as using  $>6$  times over a 2-d period. Adjusted for age, race, sex, day, weekend day, and other NS/LCS categories. †Statistically significant at  $P < 0.05$ ; \*Statistically significant at  $P < 0.001$ . LCS, low-calorie sweetener; NS, nutritive sweetener.

**TABLE 5** Mean  $\pm$  SE usual dietary intake levels of nutrients from food, beverage, and FBA items by LCS intake among US adults over 2 d stratified by BMI category<sup>1</sup>

	LCS intake		P value
	No (51.8%)	Yes (48.2%)	
<b>Normal weight<sup>2</sup></b>			
Energy, kcal	2346 $\pm$ 48.2	2080 $\pm$ 97.8	<0.001*
From food	1696 $\pm$ 41.3	1570 $\pm$ 85.8	0.004†
From beverages	517 $\pm$ 15.6	369 $\pm$ 15.0	<0.001*
From FBAs	162 $\pm$ 8.8	157 $\pm$ 12.5	0.7302
Energy density, kcal/g	0.69 $\pm$ 0.01	0.61 $\pm$ 0.02	<0.001*
Carbohydrate, g	292.9 $\pm$ 5.7	256.1 $\pm$ 11.9	<0.001*
Protein, g	83.0 $\pm$ 2.2	77.9 $\pm$ 3.2	0.004†
Total fat, g	85.2 $\pm$ 2.2	77.0 $\pm$ 4.4	<0.001*
Total sugars, g	138.1 $\pm$ 3.6	115.9 $\pm$ 3.7	<0.001*
Dietary fiber, g	17.4 $\pm$ 0.5	18.1 $\pm$ 1.0	<0.001*
<b>Overweight<sup>2</sup></b>			
Energy, kcal	2305 $\pm$ 53.8	2164 $\pm$ 58.8	<0.001*
From food	1675 $\pm$ 43.4	1648 $\pm$ 43.1	0.364
From beverages	512 $\pm$ 20.0	356 $\pm$ 12.3	<0.001*
From FBAs	157 $\pm$ 11.8	154 $\pm$ 11.8	0.6175
Energy density, kcal/g	0.68 $\pm$ 0.01	0.59 $\pm$ 0.02	<0.001*
Carbohydrate, g	285.4 $\pm$ 3.6	259.5 $\pm$ 3.4	<0.001*
Protein, g	82.7 $\pm$ 2.7	82.5 $\pm$ 3.6	0.6923
Total fat, g	85.3 $\pm$ 2.7	81.1 $\pm$ 4.4	0.1596
Total sugars, g	135.6 $\pm$ 2.5	114.7 $\pm$ 2.4	<0.001*
Dietary fiber, g	16.3 $\pm$ 0.7	18.5 $\pm$ 0.6	<0.001*
<b>Obese</b>			
Energy, kcal	2258 $\pm$ 36.1	2127 $\pm$ 51.2	0.0033†
From food	1640 $\pm$ 25.0	1662 $\pm$ 48.2	0.133
From beverages	512 $\pm$ 16.7	307 $\pm$ 9.4	<0.001*
From FBAs	150 $\pm$ 6.8	151 $\pm$ 6.7	0.8465
Energy density, kcal/g	0.66 $\pm$ 0.01	0.59 $\pm$ 0.01	<0.001*
Carbohydrate, g	281.2 $\pm$ 4.0	247.2 $\pm$ 5.1	<0.001*
Protein, g	80.2 $\pm$ 2.4	83.9 $\pm$ 1.9	0.0173†
Total fat, g	83.7 $\pm$ 1.7	84.3 $\pm$ 2.8	0.3703
Total sugars, g	133.2 $\pm$ 2.9	105.1 $\pm$ 2.2	<0.001*
Dietary fiber, g	15.5 $\pm$ 0.4	16.7 $\pm$ 0.5	<0.001*

<sup>1</sup>Adjusted for: age, race, sex, day, and weekend day. Sample: 13,688 people representative of 212,902,300 adults nationally. BMI (kg/m<sup>2</sup>) was defined as: normal weight (18.5–24.9), overweight (25–29.9), or obese ( $\geq$ 30). Those with underweight (<18.5,  $n = 237$ ) or missing ( $n = 173$ ) BMIs were excluded. †Statistically significant at  $P < 0.05$ ; \*statistically significant at  $P < 0.001$ . FBA, food and beverage addition; LCS, low-calorie sweetener.

<sup>2</sup>Ten percent of individuals with a normal-weight BMI used LCSs and 20.0% did not, 15.1% of individuals with an overweight BMI used LCSs and 18.6% did not, and 18.2% of individuals with an obese BMI used LCSs and 17.8% did not use LCSs.

LCS and other sweeteners included in this analysis was limited by the FNDDS database, which may differ based on subject demographics, BMI, or other factors. Despite the potential limitations of NHANES and FNDDS, it is the most comprehensive nationally representative data for dietary intake studies in the United States. Further, the USDA's Automated Multiple-Pass Method used to collect the dietary intake data aims to minimize misreporting of all food, beverage, and FBA items (33, 34). A third limitation is the cross-sectional design which limits our scope to associations and prevents examination of temporal relations between the factors examined. Unlike previous reports of only beverages, we examined all food, beverage, and FBA items reported in two 24-h periods along with macronutrient intake. In addition, we used

existing FNDDS food group categories to examine the food items, along with similar grouping for all beverages reported in order to assess LCSs among all items.

In conclusion, our findings indicate that individuals who report intake of LCS-containing items, alone or in combination with no or low NSs, have lower total energy intake than individuals without reported LCS intake and with reported LCS intake with high NSs. These data confirmed that the main source of LCSs in the US adult diet was beverages at roughly 32% but identified that a quarter of the US adult population consumed LCSs from FBAs with only 9% having foods as a LCS source. These results provide significant new understanding of eating patterns in the United States and thus targets for specific dietary education and intervention.

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### References

- Anderson GH, Foreyt J, Sigman-Grant M, Allison DB. The use of low-calorie sweeteners by adults: impact on weight management. *J Nutr* 2012;142(6):1163S–9S.
- Piernas C, Mendez MA, Ng SW, Gordon-Larsen P, Popkin BM. Low-calorie- and calorie-sweetened beverages: diet quality, food intake, and purchase patterns of US household consumers. *Am J Clin Nutr* 2014;99(3):567–77.
- Gardner C, Wylie-Rosett J, Gidding SS, Steffen LM, Johnson RK, Reader D, Lichtenstein AH; American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity and Metabolism, Council on Arteriosclerosis, Thrombosis and Vascular Biology, Council on Cardiovascular Disease in the Young, and the American Diabetes Association. Nonnutritive sweeteners: current use and health perspectives: a scientific statement from the American Heart Association and the American Diabetes Association. *Circulation* 2012;126(4):509–19.
- Tate DF, Turner-McGrievy G, Lyons E, Stevens J, Erickson K, Polzien K, Diamond M, Wang X, Popkin B. Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *Am J Clin Nutr* 2012;95(3):555–63.
- Peters JC, Wyatt HR, Foster GD, Pan Z, Wojtanowski AC, Vander Veur SS, Herring SJ, Brill C, Hill JO. The effects of water and non-nutritive sweetened beverages on weight loss during a 12-week weight loss treatment program. *Obesity (Silver Spring)* 2014;22(6):1415–21.
- Rogers PJ, Hogenkamp PS, de Graaf C, Higgs S, Lluch A, Ness AR, Penfold C, Perry R, Putz P, Yeomans MR, et al. Does low-energy sweetener consumption affect energy intake and body weight? A systematic review, including meta-analyses, of the evidence from human and animal studies. *Int J Obes (Lond)* 2016;40(3):381–94.
- Fowler SP, Williams K, Hazuda HP. Diet soda intake is associated with long-term increases in waist circumference in a biethnic cohort of older adults: the San Antonio Longitudinal Study of Aging. *J Am Geriatr Soc* 2015;63(4):708–15.

8. Fowler SP, Williams K, Resendez RG, Hunt KJ, Hazuda HP, Stern MP. Fueling the obesity epidemic? Artificially sweetened beverage use and long-term weight gain. *Obesity* (Silver Spring) 2008;16(8):1894–900.
9. Bleich SN, Wolfson JA, Vine S, Wang YC. Diet-beverage consumption and caloric intake among US adults, overall and by body weight. *Am J Public Health* 2014;104(3):e72–8.
10. Leahy M, Ratliff JC, Riedt CS, Fulgoni VL. Consumption of low-calorie sweetened beverages compared to water is associated with reduced intake of carbohydrates and sugar, with no adverse relationships to glycemic responses: results from the 2001–2012 National Health and Nutrition Examination Surveys. *Nutrients* 2017;9(9):928.
11. Sylvetsky AC, Rother KI. Trends in the consumption of low-calorie sweeteners. *Physiol Behav* 2016;164(Pt B):446–50.
12. Swithers SE, Davidson TL. A role for sweet taste: calorie predictive relations in energy regulation by rats. *Behav Neurosci* 2008;122(1):161–73.
13. Swithers SE, Sample CH, Davidson TL. Adverse effects of high-intensity sweeteners on energy intake and weight control in male and obesity-prone female rats. *Behav Neurosci* 2013;127(2):262–74.
14. Boakes RA, Kendig MD, Martire SI, Rooney KB. Sweetening yoghurt with glucose, but not with saccharin, promotes weight gain and increased fat pad mass in rats. *Appetite* 2016;105:114–28.
15. Drewnowski A, Rehm CD. Consumption of low-calorie sweeteners among U.S. adults is associated with higher Healthy Eating Index (HEI 2005) scores and more physical activity. *Nutrients* 2014;6(10):4389–403.
16. Sylvetsky AC, Welsh JA, Brown RJ, Vos MB. Low-calorie sweetener consumption is increasing in the United States. *Am J Clin Nutr* 2012;96(3):640–6.
17. Zick CD, Stevens RB. Time spent eating and its implications for Americans' energy balance. *Soc Indic Res* 2011;101(2):267–73.
18. Sylvetsky AC, Jin Y, Clark EJ, Welsh JA, Rother KI, Talegawkar SA. Consumption of low-calorie sweeteners among children and adults in the United States. *J Acad Nutr Diet* 2017;117(3):441–8. e2.
19. An R. Beverage consumption in relation to discretionary food intake and diet quality among US adults, 2003 to 2012. *J Acad Nutr Diet* 2016;116(1):28–37.
20. Gibson SA, Horgan GW, Francis LE, Gibson AA, Stephen AM. Low calorie beverage consumption is associated with energy and nutrient intakes and diet quality in British adults. *Nutrients* 2016;8(1):9.
21. Toozé JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, Guenther PM, Carroll RJ, Kipnis V. A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. *J Am Diet Assoc* 2006;106(10):1575–87.
22. Souverein OW, Dekkers AL, Geelen A, Haubrock J, de Vries JH, Ocke MC, Harttig U, Boeing H, van 't Veer P; EFCOVAL Consortium. Comparing four methods to estimate usual intake distributions. *Eur J Clin Nutr* 2011;65(Suppl 1):S92–101.
23. NCI Division of Cancer Control & Population Sciences. Usual dietary intakes: the NCI method. Bethesda, MD: The National Cancer Institute's Division of Cancer Control and Population Sciences; 2015 [cited 2017 July 31]. Available from: <https://epi.grants.cancer.gov/diet/usualintakes/method.html>.
24. CDC. About the National Health and Nutrition Examination Survey. Atlanta, GA: CDC/National Center for Health Statistics; 2017 [cited 2017 July 31]. Available from: [https://www.cdc.gov/nchs/nhanes/about\\_nhanes.htm](https://www.cdc.gov/nchs/nhanes/about_nhanes.htm).
25. Johnson CL, Paulose-Ram R, Ogden CL, Carroll MD, Kruszon-Moran D, Dohrmann SM, Curtin LR. National Health and Nutrition Examination Survey: analytic guidelines, 1999–2010. National Center for Health Statistics. *Vital Health Stat* 2013;161:1–24.
26. Martin CL, Montville JB, Steinfeldt LC, Omolewa-Tomobi G, Heendeniya KY, Adler ME, Moshfegh AJ. USDA Food and Nutrient Database for Dietary Studies 2011–2012: Documentation and User Guide. Beltsville, MD: US Department of Agriculture, Agricultural Research Service, USDA Food Surveys Research Group; 2012 [updated October 2014]. Available from: [https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/fndds/fndds\\_2011\\_2012\\_doc.pdf](https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/fndds/fndds_2011_2012_doc.pdf).
27. DellaValle DM, Malek AM, Hunt KJ, St. Peter JV, Greenberg D, Marriott BP. Low calorie sweeteners in foods, beverages, and food and beverage additions: NHANES 2007–2012. *Curr Dev Nutr* 2018; <https://doi.org/10.1093/cdn/nzy024>.
28. CDC, NCHS. National Health and Nutrition Examination Survey: analytic guidelines, 2011–2012. Statistics 2013. Available from: <https://stacks.cdc.gov/view/cdc/44830>.
29. Drewnowski A, Rehm CD. Socio-demographic correlates and trends in low-calorie sweetener use among adults in the United States from 1999 to 2008. *Eur J Clin Nutr* 2015;69(9):1035–41.
30. Piernas C, Ng SW, Popkin B. Trends in purchases and intake of foods and beverages containing caloric and low-calorie sweeteners over the last decade in the United States. *Pediatr Obes* 2013;8(4):294–306.
31. Murakami K, Livingstone MB. Associations between meal and snack frequency and diet quality in US adults: National Health and Nutrition Examination Survey 2003–2012. *J Acad Nutr Diet* 2016;116(7):1101–13.
32. Briefel RR, Sempos CT, McDowell MA, Chien S, Alaimo K. Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *Am J Clin Nutr* 1997;65(4 Suppl):1203S–9S.
33. Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler WV, Paul DR, Sebastian RS, Kuczynski KJ, Ingwersen LA, et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *Am J Clin Nutr* 2008;88(2):324–32.
34. Ahuja JKC, Montville JB, Omolewa-Tomobi G, Heendeniya KY, Martin CL, Steinfeldt LC, Anand J, Adler ME, LaComb RP, Moshfegh AJ. Appendix C. Dietary methods research: overview of What We Eat in America food categories: FSRG-defined food groups. Beltsville, MD: Department of Agriculture, Agricultural Research Service, USDA Food Surveys Research Group; 2012 [updated October 2014]. Available from: [http://www.ars.usda.gov/SP2UserFiles/Place/80400530/pdf/fndds/fndds\\_5\\_doc.pdf#page=64](http://www.ars.usda.gov/SP2UserFiles/Place/80400530/pdf/fndds/fndds_5_doc.pdf#page=64).