Trends in added sugars from packaged beverages available and purchased by US households, 2007–2012

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ABSTRACT

Background: The US Food and Drug Administration's updated nutrition labeling requirements will include added sugars starting in July 2018, but no measure currently exists to identify the added sugar content of products and what it represents among purchases. Beverages are one of the first targets for reducing added sugar consumption, and hence are the focus here.

Objective: Our goal was to estimate trends in added sugars in nonalcoholic packaged beverage products available in the United States and to estimate amounts of added sugars obtained from these beverages given the purchases of US households overall and by subpopulations.

Design: On the basis of nutrition label data from multiple sources, we used a stepwise approach to derive the added sugar content of 160,713 beverage products recorded as purchased by US households in 2007–2012 (345,193 observations from 110,539 unique households). We estimated the amounts of added sugars obtained from packaged beverages US households reported buying in 2007–2008, 2009–2010, and 2011–2012, overall and by subpopulations based on household composition, race/ethnicity, and income. The key outcomes are added sugars in terms of per capita grams per day and the percentage of calories from packaged beverages.

Results: Packaged beverages alone account for per capita consumption of 12 g/d of added sugars purchased by US households in 2007–2012, representing 32–48% of calories from packaged beverages. Whereas the absolute amount of added sugars from beverages has not changed meaningfully over time, the relative contribution of added sugars to calories from beverages has increased. Non-Hispanic black households and low-income households obtain both higher absolute and relative amounts of added sugars from beverages than non-Hispanic white households and high-income households (all $P < 0.01$).

Conclusions: These results provide measures of added sugars from packaged beverages at both the product level and the population level in the United States and can be used for comparisons after the revised nutrition labels are implemented and for future monitoring. *Am J Clin Nutr* 2017;106:179–88.

Keywords: added sugars, beverages, purchases, monitoring, United States

INTRODUCTION

In May 2016, the US Food and Drug Administration (FDA) updated the food labeling regulations. Major manufacturers are to apply these by 26 July 2018, and manufacturers with <$10 million in annual food sales must apply them by 26 July 2019 (1). The new regulations require that added sugars being reported on the nutrition labels of packaged foods and beverages use an expanded definition: "sugars that are either added during the processing of foods, or are packaged as such, and include sugars (free, monosaccharides, and disaccharides), sugars from syrups and honey, and sugars from concentrated fruit or vegetable juices …" (2). The definition excludes fruit or vegetable juice concentrated from 100% fruit juice that is sold to consumers (e.g., frozen 100% fruit juice concentrate), as well as some sugars found in fruit and vegetable juices, jellies, jams, preserves, and fruit spreads (2). FDA regulations do not include alcoholic beverages, for which nutrition labels are not required.

Given the growing public health concerns with added sugars, a key topic of interest is the amount of added sugars in products before the updated labeling requirements and expanded definition of added sugar, with the anticipation that added sugar content might change as the new requirements are implemented. Of particular interest are added sugars in beverages, which have been the focus of policies and recommendations to reduce added sugar consumption (3–5).

However, several challenges exist when examining sugars added to packaged foods and beverages, the supply of which is dynamic, with rapid changes in the types and amounts of caloric and low-calorie sweeteners in use (6, 7). The USDA food composition tables struggle to keep up with these changes (6, 8, 9); the NHANES captures only ∼7600 unique foods in each of the 2-y waves, compared with >85,000 uniquely formulated products available in the marketplace (7, 8). Moreover, whereas total sugars are already required on nutrition labels, amounts of

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Supplemental Figures 1 and 2 and Supplemental Tables 1–5 are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://ajcn.nutrition.org.

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Abbreviations used: FDA, Food and Drug Administration; FPL, federal poverty level; NFL, nutrition facts label; RTD, ready-to-drink.

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added sugars cannot be discerned empirically because they are not chemically distinguishable from sugars that occur intrinsically (e.g., lactose in dairy products).

This article has 3 major objectives. First, we provide estimates of added sugars in packaged nonalcoholic beverage products using a stepwise approach that includes a linear programming method (10) to show how added sugar content in beverage products may have changed over time (2007–2012). Second, we place these estimates in the context of packaged beverage purchases to understand what these changes at the product level translate to for consumers, given their purchasing choices. Third, we examine whether added sugars purchased differ by US households with and without children, and by socioeconomic and racial-ethnic subpopulations.

METHODS

Household purchase and nutrition facts label data

For this work we used the Nielsen Homescan Consumer Panel (Homescan) data on household purchases from 2007 to 2012, along with nutrition facts label (NFL) data from multiple sources between 2007 and 2012 (11, 12). Details on Homescan are available elsewhere (11–16).

Briefly, Homescan is an ongoing panel survey of households that report purchases of packaged foods and beverages. These data are collected through the use of scanners distributed to participating households that were sampled in 76 markets (52 metropolitan and 24 nonmetropolitan areas); 50,000–60,000 households were sampled each year in 2007–2012. Participants are told to scan all products with a barcode from each shopping event, and those who do so for ≥10–12 mo are retained in the analysis. This study includes 345,193 observations from 110,539 unique households that participated in 2007–2012 (see **Supplemental Figure 1**).

Homescan provides detailed information about each packaged and barcoded food and beverage purchase from all major outlet channels, the date of the shopping episode, the number of units or packages, their total weight, and the total amount paid for each barcoded item (11). Unpackaged food and beverage purchases (e.g., loose fruits and vegetables, deli meats, hot foods, fountain drinks) are not scanned nor were they included in this study. Homescan also includes sociodemographic information about household composition, income, education (highest educational attainment across all available heads of household) and race/ethnicity (preference for female head of household's race/ethnicity over male head of household's when both are available and different), age and sex of all household members, and household sampling weights. These data are used by researchers, particularly agricultural and marketing economists, to analyze food demand, consumption, branding, and promotion strategies (13–15, 17). Several studies investigating the representativeness of the Homescan data from 2008 reported some sample selection and participation biases (16), but these and other studies report that such biases can be adjusted for through the use of household demographics, such as female head of household, income, and household size (15), which we included in our models.

For the purposes of future work linking these data to What We Eat in America, the dietary component of NHANES, we grouped these data into 2-y waves (2007–2008, 2009–2010 and 2011–2012). Because it is possible to have multiple records for the same product and because the product might be reformulated within each 2-y wave, we kept records for the same barcode if the nutrient content, ingredients, or package size changed using the date to distinguish them. Records were categorized into 13 mutually exclusive beverage categories (see **Supplemental Table 1** for a description and examples).

To link the barcode-date level NFL and derive values for added sugar in nonalcoholic packaged beverage products purchased by US households, we used a systematic linking strategy that applied NFL and derived added sugar content per 100 g of products that have direct links to other purchased products of the same brand and product line but different package sizes, as described elsewhere (12). This resulted in 51,304 beverage barcodes for 2007–2008, 54,750 beverage barcodes for 2009–2010, and 54,659 beverage barcodes for 2011–2012 (a total of 160,713 beverage barcode records over the 3 waves).

Deriving added sugar values from nonalcoholic packaged beverage products

Table 1 provides an overview of the stepwise approach used and the resultant sample sizes of beverage product records included in this study. For products in step 4, as described in Table 1, we used a linear programming approach to estimate the added sugar values. A complete description of the linear programming model used to estimate quantities of added sugars has been previously published (10). Briefly, the process for estimating added sugar values requires 3 pieces of information: the NFL and ingredient lists (both from NFL databases) and the nutrient composition for each ingredient from the ESHA Ingredient Database (18). We used a linear programming approach to estimate the amount of each ingredient necessary in a given product to produce a nutrient profile as close as possible to that reported on its NFL. To help develop accurate estimates, constraints were applied to ingredients through the use of information gathered from FDA labeling regulations, scientific journals, and knowledge of typical manufacturing processes. Once formulations were estimated, we calculated the added sugar content (grams per 100 g) of each product by summing the amounts of sugar from ingredients defined as added sugars.

Analysis of added sugar content of packaged nonalcoholic beverage products

Using these beverage product–level data, but without accounting for the popularity of each product, we described the presence of added sugars in products within each beverage category in 2007–2008, 2009–2010, and 2011–2012 (the proportion of products that contain added sugars). Then, using the derived added sugar values, we described the distribution of the grams of added sugar per 100 g of the product for each beverage group over time by calculating the mean, 25th percentile, 50th percentile (median), and 75th percentile. We used *t* tests to compare the mean added sugar content of products over time (relative to 2007–2008), noting when $P < 0.05$. We used the nonparametric two-sample Mann-Whitney *U* test (also called Mann-Whitney-Wilcoxon test and Wilcoxon rank sum test) to compare the medians of added sugar contents of 2009–2010

TABLE 1
Stepwise approach to deriving added sugar content of packaged beverage products[1]

		Beverage product records with NFL data			Beverage product records of reported purchases linked to the NFL		
Step	Description of step	2007–2008	2009–2010	2011–2012	2007–2008	2009–2010	2011–2012
1	Beverage products that contain 0 g total sugar on NFL. Added sugar = 0 g	3409 (22.5)	3790 (23.0)	4277 (22.7)	22,949 (43.3)	24,860 (44.2)	24,653 (43.7)
2	Beverage products that contain >0 g total sugar or are missing a total sugar value on the NFL but have no added sugar listed on the ingredient list. Added sugar = 0 g	3685 (24.3)	3762 (22.8)	4282 (22.7)	11,439 (21.6)	10,815 (19.2)	9893 (17.5)
3	Beverage products that contain >0 g total sugar on (and sugars are not missing from) the NFL, and the only sugar-containing ingredients are added sugars (may include other ingredients that do not contain sugar, such as water and chia seeds). Added sugar = total sugar	2616 (17.3)	3224 (19.5)	3756 (19.9)	5707 (10.8)	8888 (15.8)	9260 (16.4)
4	Beverage products that contain >0 g total sugar on (and sugars are not missing from) the NFL, and have added sugars listed on the ingredient list along with other ingredients that contribute intrinsic sugar (e.g., milk). Added sugar is estimated through the use of linear programming.	4570 (30.1)	4962 (30.1)	5671 (30.1)	11,217 (21.2)	10,187 (18.1)	10,854 (19.2)
5	Beverage products that went through step 4 but had high error values, or beverage products that had a total sugar value missing from the NFL but had added sugar listed on the ingredient list. Added sugar = missing	884 (5.8)	777 (4.7)	874 (4.6)	1640 (3.1)	1513 (2.7)	1770 (3.1)
	Total	15,164	16,515	18,860	52,952	56,263	56,430

[1] Data are *n* (%). Percentages might not add up to 100% because of rounding. NFL, nutrition fact label.

relative to 2007–2008, and of 2011–2012 relative to 2007–2008, noting when $P < 0.05$. We used the nonparametric two-sample Siegel-Tukey test to compare the distributions of added sugar contents of 2009–2010 relative to 2007–2008, and of 2011–2012 relative to 2007–2008, noting when $P < 0.05$. All analyses were done in SAS version 9.4 (20).

Analysis of added sugars from packaged nonalcoholic beverage products purchased by US households in 2007–2012

Using the Homescan data on household purchases from 2007 to 2012 along with the added sugar values derived as described above, we were able to determine the amount of added sugars obtained from packaged nonalcoholic beverages reported as purchased. The key outcomes are per capita (adult equivalence) added sugars in terms of grams per day from packaged beverages in absolute terms, and added sugar calories from packaged beverages in terms of both percentage of calories from packaged nonalcoholic beverages and percentage of calories from packaged food and nonalcoholic beverages. To provide context for the derived amounts of added sugar, we also present the total sugar amounts from the NFLs, such that the difference between the derived added sugar amount and the NFL total sugar amount is the assumed intrinsic sugar amount (all in terms of per capita grams per day).

To appropriately investigate changes in added sugars from packaged beverages purchased in each of the 2-y waves, we needed to adjust for various sociodemographic and geographic factors that may be associated with beverages purchased in the United States. Given the structure of the data, with repeated measures for households, we ran maximum likelihood random-effects models with clustering at the household level. We predicted the outcomes after adjusting for household composition (number of household members from various age group and sex combinations), highest education of the head of the household (less than high school, high school or some college, college graduate or higher), race/ethnicity of the head of the household (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other), household income relative to the federal poverty level (FPL) (<185%, 185–400%, and ≥400% FPL), the proportion of packaged beverage sales by volume that has missing added sugar values, year, and Nielsen market.

We also predicted the added sugar values from packaged beverages in each wave among subsamples of households based on *1*) composition [households with any child (≤18 y) compared with households with only adults (reference)]; *2*) race/ethnicity of the head of the household [non-Hispanic white (reference), non-Hispanic black, Hispanic, non-Hispanic other], and; *3*) income [<185% FPL compared with 185–400% FPL compared with ≥400% FPL (reference)]. Using 2007–2008 as the reference wave, we compared the later waves with 2007–2008. Using the reference categories noted above, we compared the amount of added sugars from the purchases for the subsamples of households, noting when $P < 0.05$. All analyses were performed with Stata software version 14 (StataCorp, LP).

RESULTS

Added sugar content of packaged nonalcoholic beverage products

Figure 1 describes the percentage of nonalcoholic beverage products with NFL data (*N* over all waves = 160,713) that

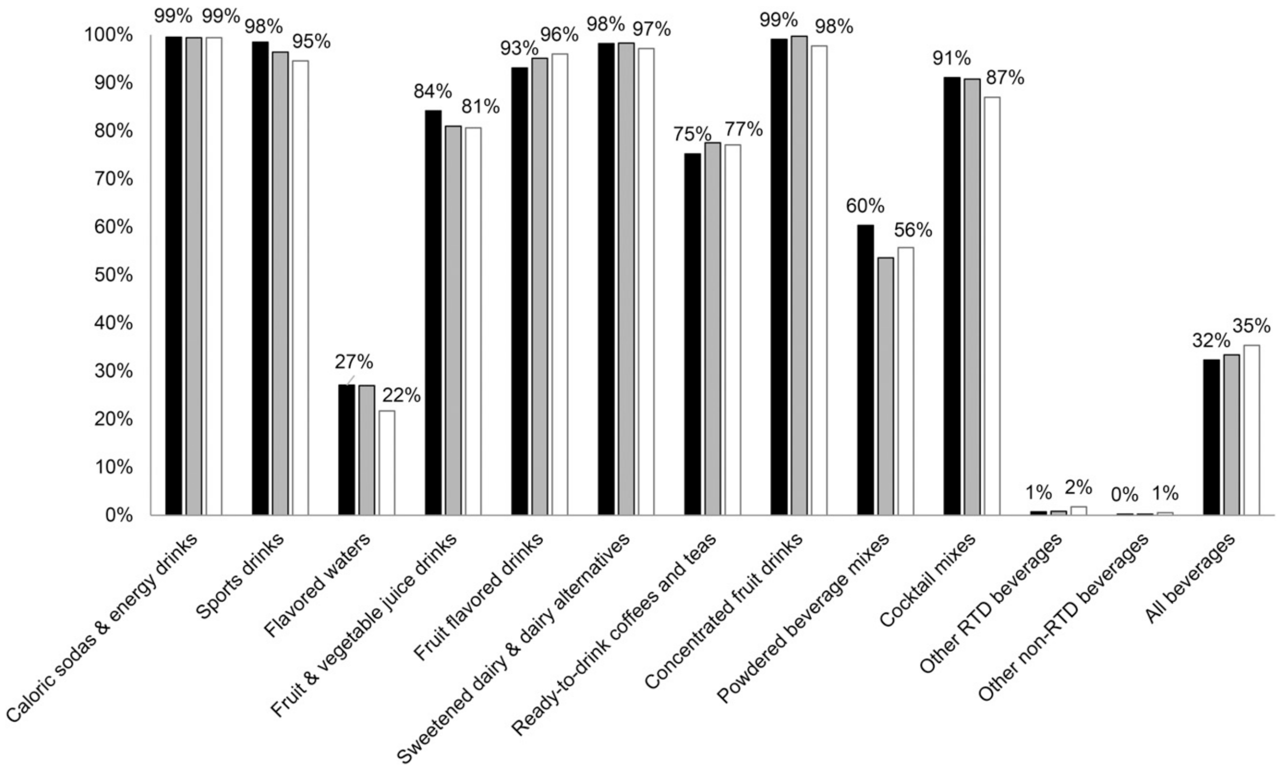

FIGURE 1 Percentage of products, by beverage category, that contain added sugars in 2007–2012. Omitted from this graph are 100% fruit and vegetable juices and juice concentrates, because all products contain 0 g added sugars, following FDA regulations. Black bars, 2007–2008 (*n* = 51,304); gray bars, 2009–2010 (*n* = 54,750); white bars, 2011–2012 (*n* = 54,659). RTD, ready-to-drink.

contain any added sugars, by 12 of the 13 beverage categories and over all these beverage categories. We do not include 100% fruit and vegetable juice and juice concentrates because, following the new FDA labeling requirements, they do not contain added sugar. We found that ∼32–35% of all nonalcoholic beverage products consistently contained added sugars over this 6-y period. Among ready-to-drink (RTD) beverages, virtually all (>99%) caloric sodas and energy drinks, >95% of sports drinks and sweetened dairy and dairy alternatives, 93–96% of fruit-flavored drinks, 81–84% of fruit and vegetable juice drinks, 75–78% of RTD coffees and teas, and 22–27% of flavored waters contain added sugars. Among non-RTD beverage products, >98% of concentrated fruit drinks, 87–91% of cocktail mixes, and 56–60% of powdered beverage mixes contain added sugars.

Figure 2 shows the unweighted derived added sugar values for RTD packaged beverages and for non-RTD packaged beverages for every 100 g of the product. Among RTD beverages (Figure 2A), caloric sodas and energy drinks consistently have the highest added sugar content (at the mean and the 25th, 50th, and 75th percentiles) compared with other beverage categories, whereas the opposite is true of flavored waters. We also see that the range of added sugar content is much narrower for caloric sodas and energy drinks, sports drinks, and flavored waters, but much wider for fruit and vegetable juice drinks, and RTD coffees and teas. The means relative to the medians (50th percentiles) provide an indication of the skewness of the distribution of the added sugar content, such that when the median is higher than the mean, a larger proportion of products are on the higher end of the added sugar distribution for that beverage category. This is clearly the case for sports drinks, fruit and vegetable juice drinks, fruit-flavored drinks, and RTD coffees and teas. The opposite is true for flavored waters and sweetened dairy and dairy alternatives.

Not surprisingly, given the nonreconstituted nature of non-RTD beverage products, they have much more added sugar per 100 g of the product (Figure 2B). We found a very high heterogeneity in added sugar content for powdered beverage mixes, but a much narrower distribution for concentrated fruit drinks.

Supplemental Table 2 presents the derived added sugar content by beverage groups at the mean and the 25th, 50th, and 75th percentiles, along with the statistical tests for the mean, median, and distributions. In looking at the added sugar content within beverage categories over time, we found statistically significant reductions in the mean added sugar content of caloric sodas and energy drinks, sports drinks, fruit and vegetable juice drinks, powdered beverage mixes, and cocktail mixes in 2009–2010 and 2011–2012 compared with 2007–2008 ($P < 0.05$).

The median added sugar content was also reduced in caloric sodas and energy drinks, fruit and vegetable juice drinks, and powdered beverage mixes in 2009–2010 and 2011–2012 compared with 2007–2008 ($P < 0.05$), and for RTD coffees and teas and cocktail mixes in 2011–2012 compared with 2007–2008 ($P < 0.05$). On the other hand, whereas no statistically significant increases occurred at the mean, median added sugar content did increase for fruit flavored drinks in 2009–2010 compared with 2007–2008, and for sweetened dairy and dairy alternatives

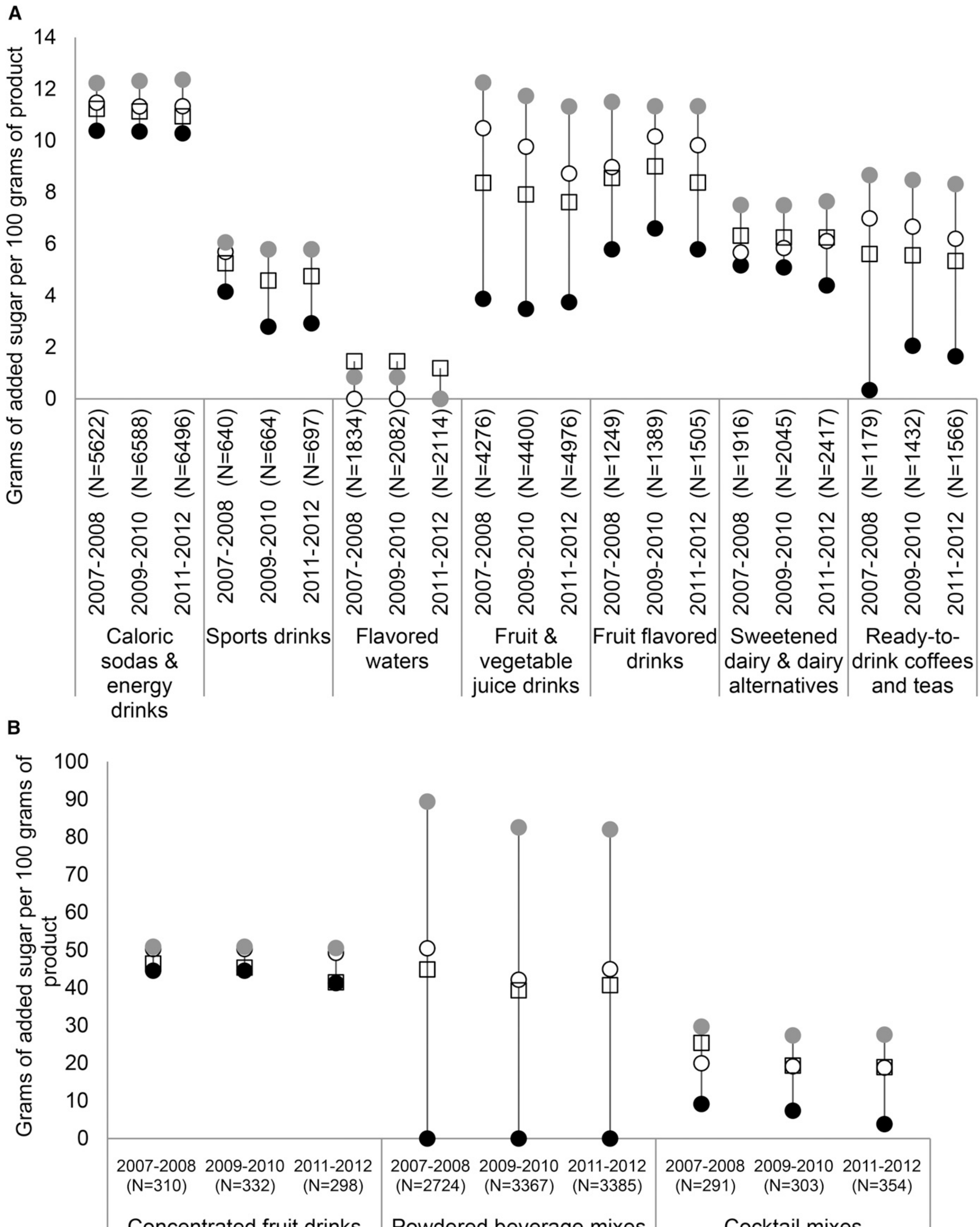

FIGURE 2 Derived added sugar content [grams per 100 g product; mean (white squares) and 25th (black circles), 50th (white circles), and 75th (gray circles) percentiles] in RTD (A) and non-RTD (B) beverage categories in 2007–2012. Omitted from these graphs are 100% fruit and vegetable juices and juice concentrates, because all products contain 0 g added sugars, following FDA regulations. Other RTD and non-RTD categories are also omitted because added sugar values were very close to 0 g. RTD, ready-to-drink.

in 2009–2010 and 2011–2012 compared with 2007–2008 ($P < 0.05$).

In tests of the full distribution of added sugar content for each beverage group, we found statistical differences between 2009–2010 and 2007–2008 for caloric sodas and energy drinks, fruit and vegetable juice drinks, fruit-flavored drinks, sweetened dairy and dairy alternatives, and concentrated fruit drinks ($P < 0.05$). In comparisons of 2011–2012 and 2007–2008, the added sugar content distributions for sports drinks, flavored waters, RTD coffees and teas, and other non-RTD beverages were also statistically different ($P < 0.05$).

Added sugars from packaged nonalcoholic beverage products purchased by US households in 2007–2012

Figure 3 shows the survey-weighted but unadjusted amounts of added sugars purchased from among the beverage categories and how they contribute to the total mean added sugars from packaged beverages purchased by US households over time. The average person gets 13–14 g added sugars/d from packaged nonalcoholic beverages, of which caloric sodas and energy drinks contribute the most (8–9 g), followed by fruit and vegetable juice drinks (1.5 g) and powdered beverage mixes (1.3 g). No meaningful changes occurred over time in terms of the contributions of added sugars by beverage category. Although a statistically significant increase occurred in added sugars purchased in 2011–2012 compared with 2007–2008, the absolute amount (1 g) is small. **Supplemental Table 3** contains the full results, including SEs and 95% CIs.

Figure 4 shows the model-adjusted mean added sugars and total sugars (the intrinsic sugar amounts presented in Figure 4 were obtained by subtracting the added sugar from the total sugar) from packaged beverages purchased by the various subpopulations of US households. Figure 4A shows the mean across all US households and among households with any child (≤18 y) compared with households with only adults. Over time, across all US households, no statistical or meaningful reduction occurred in the amounts of added and intrinsic sugars from packaged beverages purchased. Among US households with any child, we found a small but significant increase in added sugars from beverages in 2011–2012 compared with 2007–2008. Even after adjusting for household composition (number of household members of various age groups and of each sex), households with only adults consistently purchase packaged beverages with more of both added and intrinsic sugars than did households with any child (all $P < 0.05$).

Figure 4B presents the results by racial/ethnic subpopulations, showing that non-Hispanic black households consistently obtain significantly more added sugars (and less intrinsic sugars) from beverages than do non-Hispanic white households. Meanwhile, Hispanic households obtain similar amounts of added sugars but slightly less intrinsic sugars than white households. Non-Hispanic other households obtain the least added sugars. Figure 4C shows the stark income (based on FPL) gradient of added sugars and total sugars from packaged beverages. Per capita, the

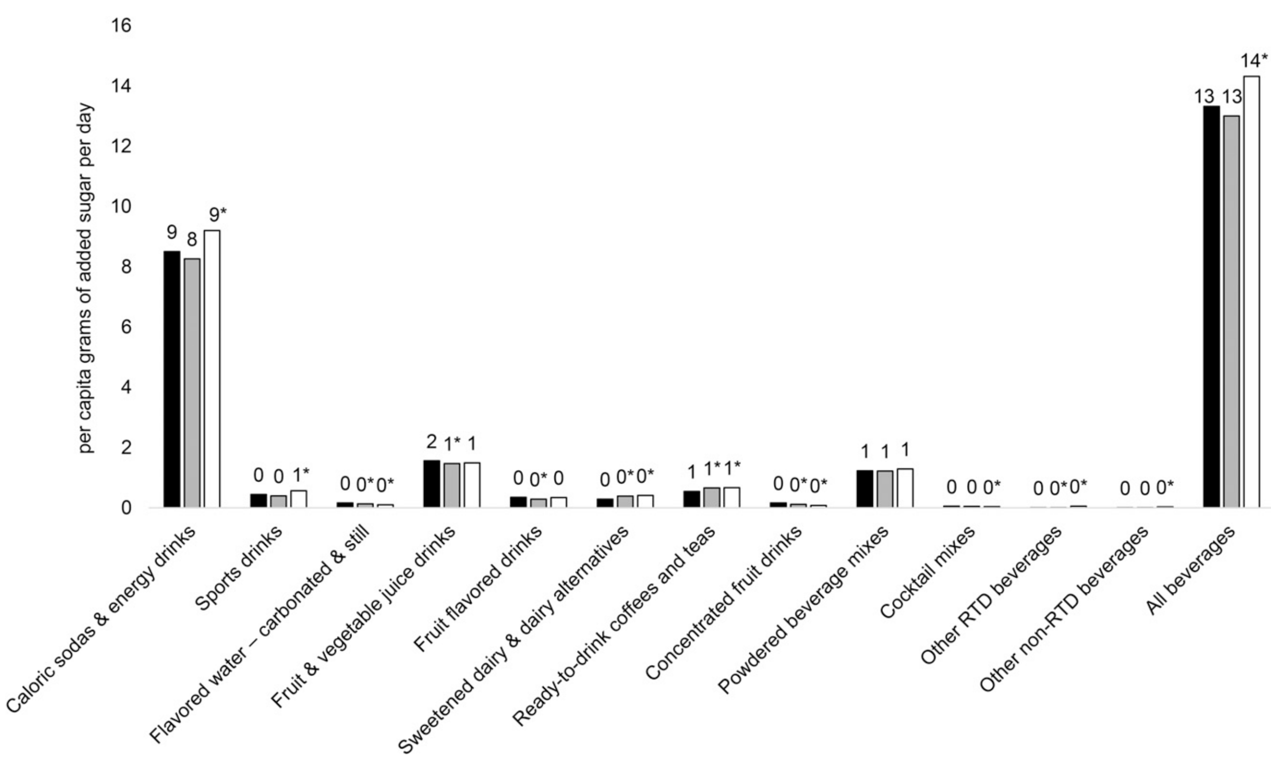

FIGURE 3 Survey-weighted unadjusted mean added sugars (per capita grams per day) from packaged beverages (by beverage category) purchased in 2007–2012. These data are from our own calculations, based in part on data reported by Nielsen through its Homescan Services for all food and beverage categories for the US market for the period 2007–2012 (New York: Nielsen Company 2017). Omitted from this graph are 100% fruit and vegetable juices and juice concentrates, because all products contain 0 g added sugars, following FDA regulations. *Statistically different from 2007 to 2008, $P < 0.05$. Black bars, 2007–2008 (HH-year n = 116,551); gray bars, 2009–2010 (HH-year n = 113,436); white bars, 2011–2012 (HH-year n = 115,206). HH, households; RTD, ready-to-drink.

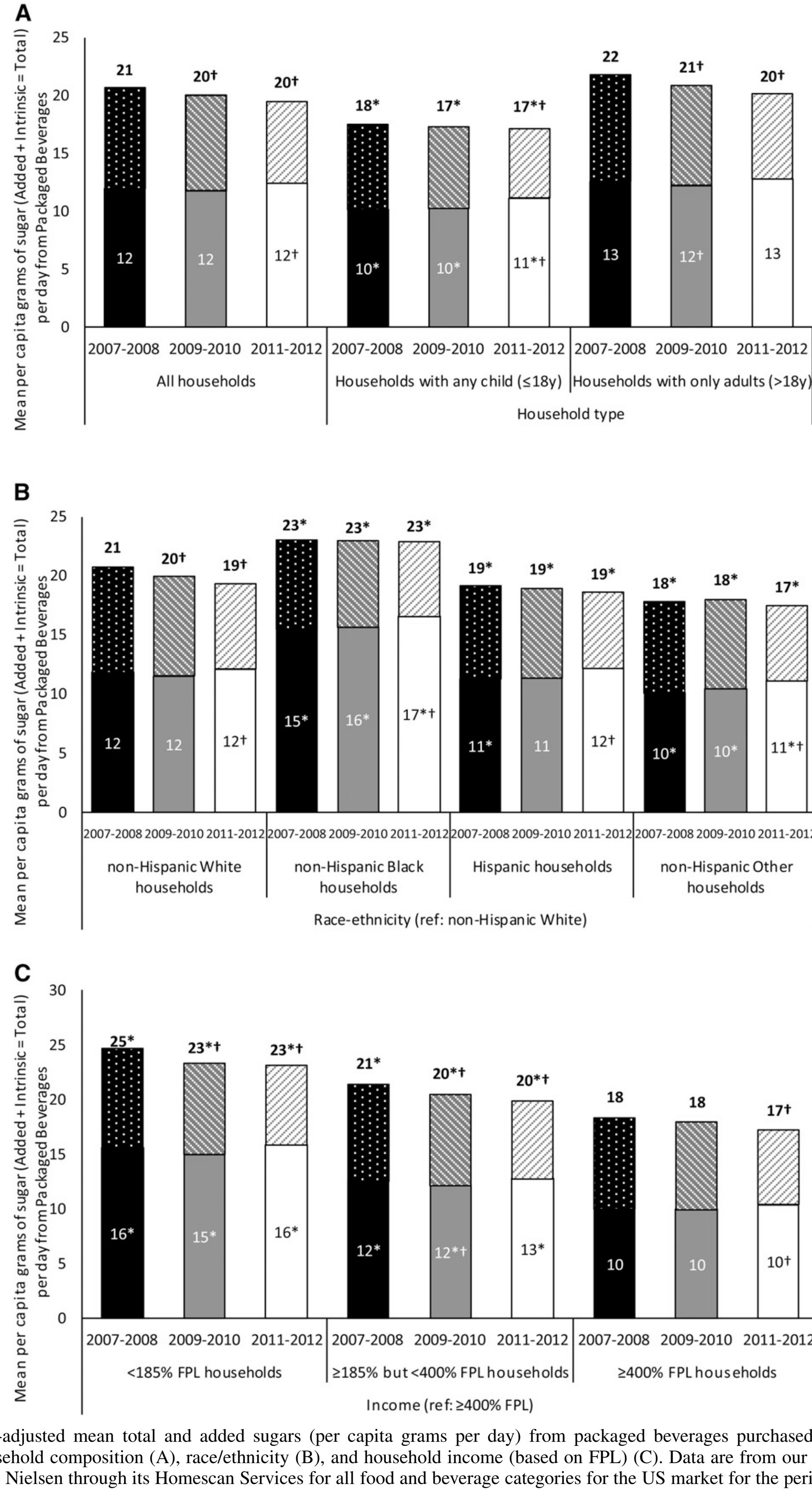

FIGURE 4 Model-adjusted mean total and added sugars (per capita grams per day) from packaged beverages purchased in 2007–2012 among all households and by household composition (A), race/ethnicity (B), and household income (based on FPL) (C). Data are from our own calculations, based in part on data reported by Nielsen through its Homescan Services for all food and beverage categories for the US market for the period 2007–2012 (New York: Nielsen Company 2017). Model adjustment uses maximum likelihood random-effects models with clustering at the household, adjusting for household composition, highest education of the head of the household, race/ethnicity of the head of the household, household income, proportion of packaged beverage sales by volume that has missing added sugar values, year, and Nielsen market. Numbers above the bars denote model-adjusted total sugar values; intrinsic sugar values were obtained by subtracting model-adjusted added sugar values from model-adjusted total sugar values. *Statistically different from reference subpopulation for the same wave, $P < 0.05$; †statistically different from 2007 to 2008, $P < 0.05$. FPL, federal poverty level.

households with the lowest incomes (<185% FPL) obtain about 6 g added sugars/d more than households with income ≥400% FPL ($P < 0.05$). Even households with income between 185% and 400% FPL obtain significantly more added sugars ($P < 0.05$). Over time, per capita consumption of total sugars from packaged beverages fell from 25 to 23 g/d ($P < 0.05$) in the households with the lowest incomes, but remained consistently higher than the 17–18 g/d in households with income ≥400% FPL. **Supplemental Table 4** contains the model-adjusted results for added and total sugars, including SEs and 95% CIs.

We illustrate the model-adjusted added sugars as a percentage of calories from packaged nonalcoholic beverages in **Figure 5**. Although the absolute amounts of added sugars did not change meaningfully over time (as shown in Figure 4), added sugars as a percentage of calories from packaged beverages (a relative measure) increased from a mean of 32% in 2007–2008 to 48% in 2011–2012. This is the case across all subpopulations we examined. Nonetheless, some clear subpopulation differences are maintained over time. Households with any child obtained a larger proportion (>9 percentage points, $P < 0.05$) of beverage calories from added sugars than did households with adults only. Non-Hispanic black and Hispanic households obtained a higher percentage (>12 percentage points, $P < 0.05$; and >4 percentage points, $P < 0.05$, respectively) of beverage calories from added sugars than did non-Hispanic white households. Again, we saw an income gradient, with the households with the lowest incomes obtaining a larger proportion (>6 percentage points, $P < 0.05$) of beverage calories from added sugars compared with households with an income ≥400% FPL. Likewise, when using the total packaged food and beverage calories as the denominator, added sugar calories from beverages alone increased over time, and we found the same racial/ethnic and income gradients (**Supplemental Figure 2**). In 2011–2012, non-Hispanic black households obtained 9.1% of their calories from added sugars in packaged beverages alone (not including added sugars from foods). **Supplemental Table 5** contains the full results, including SEs and 95% CIs.

DISCUSSION

Studies in Australia, Canada, and the Netherlands have estimated the added and free sugar content of packaged foods and beverages (21–23). This study is based in the United States, focuses on beverages purchased by consumers over a 6-y period, and uses a stepwise approach that incorporates a linear programming model to estimate added sugar amounts for a larger set of products (8). More importantly, we examined the amounts of added and total sugars from packaged beverages purchased by US households and whether differences exist in the added sugars and total sugars purchased by subpopulations. These data provide the basis for comparing how added sugar in and purchases of packaged beverages may change after the revised nutrition labels are fully implemented.

We found that 32–35% of packaged beverages reported as purchased by US households consistently contain added sugars.

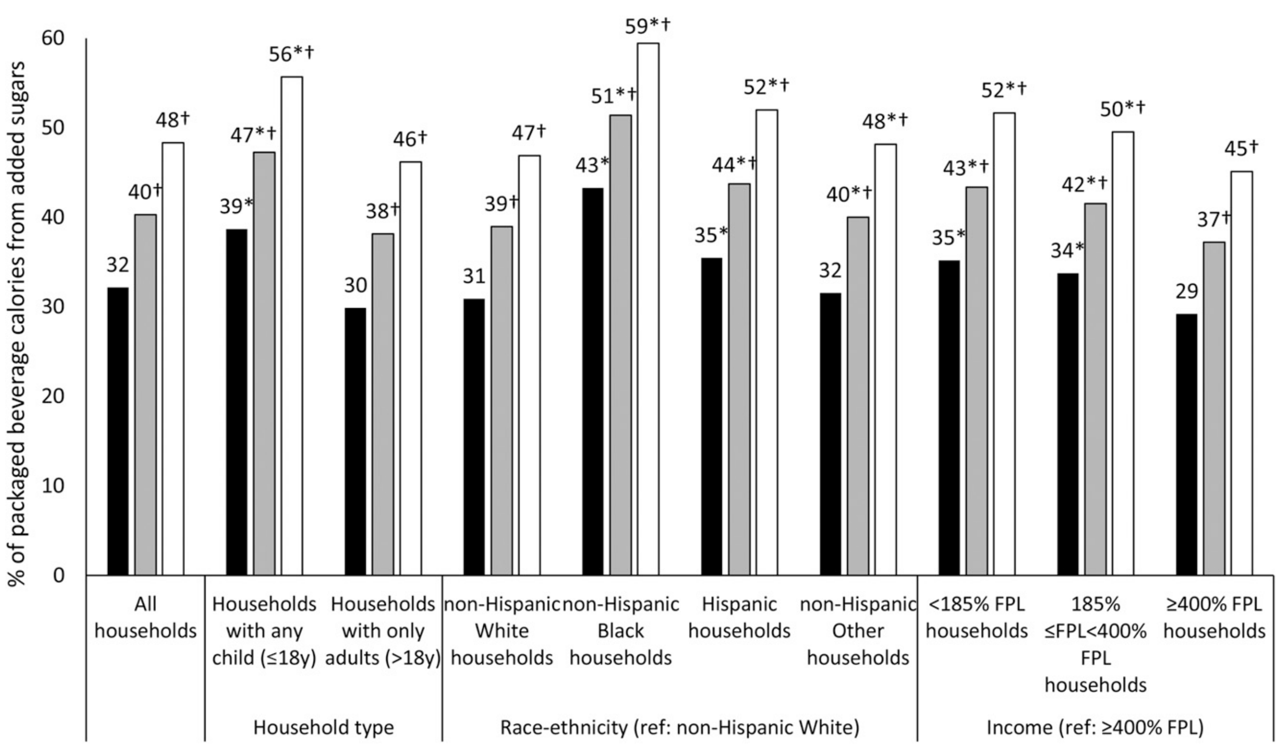

FIGURE 5 Model-adjusted percentage of packaged beverage calories from added sugars in 2007–2012, by household subpopulations. Data are from our own calculations, based in part on data reported by Nielsen through its Homescan Services for all food and beverage categories for the US market for the period 2007–2012 (New York: Nielsen Company 2017). Model adjustment uses maximum likelihood random-effects models with clustering at the household, adjusting for household composition, highest education of the head of the household, race/ethnicity of the head of the household, household income, proportion of packaged beverage sales by volume that has missing added sugar values, year, and Nielsen market. *Statistically different from the reference subpopulation for the same wave, $P < 0.05$; †statistically different from 2007 to 2008, $P < 0.05$. Black bars, 2007–2008 (HH-year n = 116,551); gray bars, 2009–2010 (HH-year n = 113,436); white bars, 2011–2012 (HH-year n = 115,206). FPL, federal poverty level; HH, households.

Larger proportions of sports drinks, fruit and vegetable juice drinks, fruit-flavored drinks, and RTD coffees and teas contain amounts of added sugar on the high ends of their distributions, whereas larger proportions of flavored waters and sweetened dairy and dairy alternatives have amounts of added sugar on the low ends of their distributions. A study in Canada found that 72% of the 1407 beverages from 4 major grocery chains contained free sugar ingredients (21). This is much higher than our finding, in part because we included in our analysis 100% fruit and vegetable juices and juice concentrates, RTD coffees and teas, and flavored waters (these beverages are much more likely to have low or no added sugars). Moreover, our lower estimates may be due to differences in the definitions of free sugar (sugar no longer in its natural state, which includes fruit juice) and FDA-defined added sugars. The number of beverage products covered by our study is also much larger because of both the larger US market and how the NFL data were obtained and matched with reported purchases. Nonetheless, the derived free or added sugar values across the studies are very comparable for the beverage groups that are the most similar.

Beyond looking at the mean added sugar content, we also investigated changes in its distribution; we found reductions in the median added sugar content of caloric sodas and energy drinks, fruit and vegetable juice drinks, and powdered beverage mixes. However, the median added sugar content increased for fruit-flavored drinks and sweetened dairy and dairy alternatives. These findings suggest that it is important to consider how added sugar content varies within beverage groups, and there is a need to monitor heterogeneity in added sugars in beverages, including highlighting the products with larger compared with smaller amounts of added sugar. For example, smartphone applications such as FoodSwitch (24) have been launched in various countries (e.g., Australia, New Zealand, United Kingdom, South Africa) to provide guidance to consumers on alternative products containing less sugar, sodium, and fat.

Once household purchases were layered, we found that across the 6 y of data, the average adult gets 12 g added sugars/d from packaged nonalcoholic beverages, of which caloric sodas and energy drinks contribute the most. We found no meaningful changes over time in terms of the contributions of added sugars by beverage category, or in the amounts of added and intrinsic sugars from packaged beverages purchased. However, added sugars as a percentage of calories from packaged beverages rose for all households, from 32% in 2007–2008 to 40% in 2009–2010, and again to 48% in 2011–2012. The relative contribution of added sugars to beverage calories has increased despite little change in the absolute added sugar values, because total beverage calories have fallen over time, likely driven by shifts toward dairy products containing less fat and reductions in the consumption of 100% fruit juices (25). These values are within the range of estimates derived by Powell et al. (26), who found that in 2009–2012, 34–39% of beverage calories came from added sugars. The higher percentage of beverage calories from added sugars found here may be because Powell et al. did not consider fruit and vegetable juice concentrates to be added sugars before 2011 (26). Meanwhile, Poti et al. (27) found that among the top sources of calories from beverages obtained from stores, 4% of calories from milks (plain and sweetened) came from added sugars, whereas 63–66% of calories from nondairy sugar-sweetened beverages came from added sugars. To provide context for these values, the WHO recommends that added sugars be limited to <10% of total energy intake, with further reductions to <5% of total energy intake (3). We found that calories from added sugars in packaged beverages alone already accounted for 3.2–6.1% of calories in 2007–2008 and 6.1–9.1% of calories in 2011–2012.

Subpopulation differences were also found and persisted over time. Although households with adults only consistently purchased larger absolute amounts of both added and intrinsic sugars from packaged beverages, they obtained a smaller proportion of beverage calories from added sugars than did households with any child. Non-Hispanic black households consistently obtained significantly more added sugars in both absolute and relative terms than did non-Hispanic white households. Likewise, the households with the lowest incomes (<185% FPL) obtained significantly more added sugars in both absolute and relative terms than did households with incomes ≥400% FPL. These findings are consistent with earlier research that found calories from store-obtained beverages decreased in all subpopulations, but reductions in calories from packaged beverages purchased in 2009–2012 were slower in black and low-income households than in white and high-income households (28). Nonetheless, earlier work on packaged beverages has only been able to consider calories or total sugars, not added sugars specifically.

As manufacturers reformulate their products to reduce the sugar content, the sugars may be increasingly replaced with low- or no-calorie sweeteners, as is already being observed (6, 7). Additional research is warranted in order to monitor the growing presence of these sweeteners in the food supply and consumer purchase and intake of them.

Major limitations of this work include our ability to consider only packaged nonalcoholic beverages in this article. Although ongoing work will allow us to expand derived added sugar values to include packaged foods from stores, we will still miss nonpackaged beverages and foods such as fountain drinks, homemade smoothies, and food service items. Moreover, with purchase data, the amount of waste or spoilage is unknown, and we are unable to determine who in the household consumed the purchased items. We were also unable to derive added sugar values for all of the packaged beverage products reported as purchased, but we included the proportion of packaged beverage sales by volume that has missing added sugar values (at the household-year level) as controls in our model adjustments.

So far we have only been able to estimate added sugars purchased, not consumed. Future work will use a "factory-to-fork" approach (8) that links the derived added sugar values to the Food and Nutrient Database for Dietary Studies to allow us to understand how these translate to intake, and to compare them with other added sugar estimates, such as from the Food Patterns Equivalents Database.

Nonetheless, to our knowledge, this work provides the first estimates of the amounts and proportions of added sugars in packaged beverages purchased by US households, and shows the large disparities that exist across certain subpopulations. These disparities must be addressed, and it is unclear whether the updated FDA labeling requirements will encourage manufacturers to reduce the amounts of added sugar in their products, educate consumers to choose products with less added sugar, and change the overall levels and subpopulation disparities.

In conclusion, we found that, after model adjustments, packaged beverages alone accounted for per capita consumption of ∼12 g added sugars/d in purchases by US households in 2007–2012, which represent 32–48% of calories from beverages. Whereas the absolute amount of added sugars from beverages has not changed meaningfully over time, the relative contribution of added sugars to beverage calories has increased. Non-Hispanic black households and low-income households obtain both higher absolute and relative amounts of added sugars from beverages than do non-Hispanic white households and high-income households. These results provide baseline measurements for the future monitoring of changes in added sugars in packaged beverages in terms of both products and what is being purchased by US households.

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REFERENCES

1. US Food and Drug Administration. Changes to the nutrition facts label [Internet]. 2016 [cited 2016 Nov 3]. Available from: http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm.
2. Nutrition labeling of food. 21 CFR Sect 101.9 c6 (iii) (2016).
3. WHO. Sugars intake for adults and children. Guideline. Geneva (Switzerland): WHO; 2015.
4. Johnson RK, Appel LJ, Brands M, Howard BV, Lefevre M, Lustig RH, Sacks F, Steffen LM, Wylie-Rosett J. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. Circulation 2009;120:1011–20.
5. DHHS and USDA. Dietary Guidelines for Americans 2015-2020". 8th ed. (ed. Office of Disease Prevention and Health Promotion, DHHS) [Internet]. 2010. [cited 2017 May 11]. Available from: https://health.gov/dietaryguidelines/2015/guidelines/.
6. 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;8:294–306.
7. Ng SW, Slining MM, Popkin BM. Use of caloric and noncaloric sweeteners in US consumer packaged foods, 2005–2009. J Acad Nutr Diet 2012;112:1828–34.e1–6.
8. Slining M, Yoon EF, Davis J, Hollingsworth B, Miles D, Ng SW. A method of monitoring foods and nutrients from factory to fork. J Acad Nutr Diet 2015;115:40–9.
9. Slining MM. Ng SW, Popkin BM. Food companies' calorie-reduction pledges to improve U.S. diet. Am J Prev Med 2013;44:174–84.
10. Ng SW, Bricker G, Li K-P, Yoon EF, Kang J, Westrich B. Estimating added sugars in US consumer packaged goods: an application to beverages in 2007–08. J Food Compost Anal 2015;43:7–17.
11. Ng SW, Popkin BM. Monitoring foods and nutrients sold and consumed in the United States: dynamics and challenges. J Acad Nutr Diet 2012;112:41–5.e4.
12. Ng SW, Slining MM, Popkin BM. The Healthy Weight Commitment Foundation pledge: calories sold from U.S. consumer packaged goods, 2007–2012. Am J Prev Med 2014;47:508–19.
13. Einav L, Leibtag E, Nevo A. On the accuracy of Nielsen Homescan data. Economic research report no. ERR-69. Washington (DC): USDA Economic Research Service; 2008.
14. Einav L, Leibtag E, Nevo A. Recording discrepancies in Nielsen Homescan data: are they present and do they matter? Quant Mark Econ 2010;8:207–39.
15. Zhen C, Taylor JL, Muth MK, Leibtag E. Understanding differences in self-reported expenditures between household scanner data and diary survey data: a comparison of Homescan and Consumer Expenditure Survey. Appl Econ Perspect Policy 2009;31:470–92.
16. Lusk JL, Brooks K. Who participates in household scanning panels? Am J Agric Econ 2011;93:226–40.
17. Aguiar M, Hurst E. Life-cycle prices and production. Am Econ Rev 2007;97:1533–59.
18. ESHA Research. ESHA ingredient database [Internet]. 2011. [cited 2017 11 May]. Available from: http://www.esha.com/products/nutrition-database-api/.
19. Sheskin DJ. Handbook of parametric and nonparametric statistical procedures. Boca Raton (FL): CRC Press; 1997.
20. SAS Institute Inc. Base SAS 9.4. Cary (NC): SAS Institute Inc; 2013.
21. Bernstein JT, Schermel A, Mills C, L'Abbé M. Total and free sugar content of Canadian prepackaged foods and beverages. Nutrients 2016;8:E582.
22. Louie JCY, Lei L, Rangan AM. Reliability of a systematic methodology to estimate added sugars content of foods when applied to a recent Australian food composition database. J Food Compost Anal 2016;46:36–42.
23. Sluik D, van Lee L, Engelen A, Feskens E. Total, free, and added sugar consumption and adherence to guidelines: the Dutch National Food Consumption Survey 2007–2010. Nutrients 2016;8:70.
24. The George Institute [Internet]. [cited 2017 May 11]. Available from: http://www.georgeinstitute.org/projects/foodswitch.
25. Ford CN, Ng SW, Popkin BM. Ten-year beverage intake trends among US preschool children: rapid declines between 2003 and 2010 but stagnancy in recent years. Pediatr Obes 2016;11:47–53.
26. Powell ES, Smith-Taillie LP, Popkin BM. Added sugars intake across the distribution of US children and adult consumers: 1977–2012. J Acad Nutr Diet 2016;116:1543–50.e1.
27. Poti JM, Slining MM, Popkin BM. Solid fat and added sugar intake among US children: the role of stores, schools, and fast food, 1994–2010. Am J Prev Med 2013;45:551–9.
28. Ng SW, Poti JM, Popkin BM. Trends in racial/ethnic and income disparities in foods and beverages consumed and purchased from stores among US households with children, 2000–2013. Am J Clin Nutr 2016;104:750–9.