# Overweight Among Low-Income Preschool Children Associated With the Consumption of Sweet Drinks: Missouri, 1999–2002

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**ABSTRACT.** *Objective.* **To examine the association between sweet drink consumption and overweight among preschool children.**

*Methods.* **A retrospective cohort design was used to examine the association between sweet drink consumption and overweight at follow-up among 10 904 children who were aged 2 and 3 years and had height, weight, and Harvard Service Food Frequency Questionnaire data collected between January 1999 and December 2001 and height and weight data collected 1 year later. Sweet drinks included vitamin C–containing juices, other juices, fruit drinks, and sodas as listed on the Harvard Service Food Frequency Questionnaire. Logistic regression was used to adjust for age; gender; race/ethnicity; birth weight; and intake of high-fat foods, sweet foods, and total calories. Results were stratified by baseline BMI.**

*Results.* **Among children who were normal or underweight at baseline (BMI <85th percentile), the association between sweet drink consumption and development of overweight was positive but not statistically significant. Children who were at risk for overweight at baseline (BMI 85th–<95th percentile) and consumed 1 to <2 drinks/day, 2 to <3 drinks/day, and ≥3 drinks/day were, respectively, 2.0 (95% confidence interval [CI]: 1.3–3.2), 2.0 (95% CI: 1.2–3.2), and 1.8 (95% CI: 1.1–2.8) times as likely to become overweight as the referent (<1 drink/day). Children who were overweight at baseline (BMI ≥95th percentile) and consumed 1 to <2 drinks/day, 2 to <3 drinks/day, and ≥3 drinks/day were, respectively, 2.1, 2.2, and 1.8 times as likely to remain overweight as the referent.**

*Conclusions.* **Reducing sweet drink consumption might be 1 strategy to manage the weight of preschool children. Additional studies are needed to understand the mechanism by which such consumption contributes to overweight.** ***Pediatrics*** **2005;115:e223–e229. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-1148;** ***child nutrition, children's growth, obesity, weight control, fruit juice, beverages, diet.***

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ABBREVIATIONS. PedNSS, Pediatric Nutrition Surveillance System; WIC, Special Supplemental Nutrition Program for Woman, Infants, and Children; HFFQ, Harvard Service Food Frequency Questionnaire; AOR, adjusted odds ratio; CI, confidence interval.

The prevalence of overweight has increased dramatically among US children. Among 2- to 5-year-olds, overweight doubled from 5% in the early 1970s to >10% in 2000.[1] Overweight children face serious health consequences, as studies have demonstrated a positive association between excess weight in childhood and increased blood pressure,[2,3] increased cholesterol and triglyceride levels,[4] diabetes,[5] respiratory disease,[6] and orthopedic[7] and psychosocial disorders.[8] In addition, overweight children seem to be more likely to become overweight adults.[9,10]

Several studies indicate that the consumption of sweet drinks, which increased 68% for carbonated soft drinks and 42% for fruit juices between 1977 and 1997, may play an important role in the obesity epidemic.[11] Two small, experimental studies of adults conducted by Raben et al[12] ($n = 41$) and Tordoff and Alleva[13] ($n = 30$) demonstrated that increased consumption of sugar-sweetened soft drinks led to increased total energy intake and an increase in body weight. In addition, Ludwig et al,[14] in a prospective study of children aged 11 and 12 years, found that the odds ratio of becoming overweight increased 60% for each serving of sugar-sweetened drink (soda, fruit drink, or iced tea) consumed daily. James et al[15] in a cluster-randomized controlled trial demonstrated that a reduction in carbonated beverage consumption was associated with a decrease in the prevalence of overweight among 7- to 11-year-olds. Finally, Troiano et al,[16] in their analysis of National Health and Nutrition Examination Survey data collected from 1988 to 1994, found a positive association between consumption of carbonated soft drinks and overweight in all age groups, including children aged 2 to 5 years.

Among preschool children, previous studies have focused on the association between consumption of fruit juice and overweight. Dennison et al,[17] in a cross-sectional study, found that children who were aged 2 and 5 years who consumed ≥12 oz/day of fruit juice were more likely (32% vs 9%) to be obese (BMI ≥90th percentile) than those who consumed less. However, longitudinal studies reported by Skinner et al[18,19] and Alexy et al[20] suggested that juice consumption has no association with the incidence of overweight. None of these studies, however, considered the impact of the consumption of other sweet drinks among preschoolers. In addition, previous longitudinal studies did not stratify by baseline BMI or examine the persistence of overweight. The objective of our research was to examine the longitudinal association between the consumption of all commonly consumed sweet drinks and the incidence and persistence of overweight among preschool children.

## METHODS

### Sample

Data for this study were collected for the Missouri Pediatric Nutrition Surveillance System (PedNSS) and the Missouri Demonstration Project through the federally funded Special Supplemental Nutrition Program for Woman, Infants, and Children (WIC). The PedNSS is a national, program-based surveillance system that was designed to monitor the nutrition status of low-income children who are enrolled in public health nutrition programs. The Missouri Demonstration Project was initiated in 1997 in part to expand the existing surveillance system to include information on diet and food insecurity using the Harvard Service Food Frequency Questionnaire (HFFQ). From 2000 to 2002, the Demonstration Project began a statewide expansion, beginning with clinics that are located in the primarily rural areas.

The mission of WIC is to assist in meeting the health and nutrition needs of low-income women, infants, and children up to 5 years of age.[21] Information collected on enrollment and every 6 months thereafter includes sociodemographic variables (race/ethnicity, age, geographic location), birth weight, anthropometric indices (height/length, weight), indicators of iron status, breastfeeding practices, and dietary patterns.[22]

The study sample included children who were aged 2 and 3 years and enrolled in the Missouri WIC Program between January 1999 and December 2001 (Fig 1). A total of 96 756 children were enrolled during this time and had at least 1 clinic visit at which height and weight data were collected and reported to the PedNSS. Of these children, 1551 were excluded from the study because their records lacked missing values for key variables, and 380 were excluded because of their extreme BMI values ($z$ score $<-4$ or $>5$). During the same time period, 45 499 of these children also had their dietary intake assessed for the Demonstration Project using the HFFQ. Of these children, 1045 were excluded because of missing values for key variables and 3077 were excluded for having extremes in total energy intake (<800 or >3500 calories). These 2 data sets were merged by unique identification number to create 1 data set that included the 37 421 children who had a complete record of a clinic visit at which baseline height, weight, and dietary data all were collected within ±2 weeks. The study sample comprised the 10 904 children who also had a follow-up clinic visit with height and weight data collected 1 year (11–13 months) later. The protocol for this study was reviewed and approved by Human Subjects Committee of the Internal Review Board at the Centers for Disease Control and Prevention.

### Variables

The outcome variable "overweight" was defined as a BMI ≥95th percentile for age and gender according to the Centers for Disease Control and Prevention growth chart.[23] BMI is measured as weight in kilograms divided by height in meters squared (kg/m$^2$). According to the protocol, the children had their standing heights measured (to the nearest 1 mm or 1/8 inch) using a standard measuring board. For weight measurements to the nearest 0.1 kg or 1/4 pound, a pediatric scale or other beam balance scale was used.

The HFFQ, originally developed by Harvard University to assess the diets of low-income women, was subsequently modified to be a dietary assessment tool for children and youths.[24] Its validity for assessing nutrient intake among children aged 1 to 5 years was tested by Blum et al,[24] who found that dietary data that were collected using the HFFQ correlated well with information collected on 3 separate 24-hour recalls completed by parents over 1 month. The average nutrient correlation was 0.52, similar to that found in validation studies of similar food frequency questionnaires among adolescents and adults.

For the present study, we defined the exposure variable "sweet drinks" as including all sugar-sweetened and naturally sweet drinks listed on the HFFQ: "vitamin C juice (orange juice or juice with vitamin C added)," "other juices," "fruit drinks (Hi-C, Kool-Aid, lemonade)," and "soda (soda, soft drink, pop [not sugar-free])." We also assessed the association between consumption and overweight when sodas were excluded from the sweet-drink exposure variable and with the consumption of fruit juice (vitamin C–containing and other) alone.

We calculated total drink consumption on the basis of responses provided by parents to the question of how often in the past 4 weeks their child consumed a parent-defined serving of the above-specified items listed on the standardized, self-administered form. Response options included in the last 4 weeks (0 or 1–3 times), each week (1, 2–4, or 5–6 times), or each day (1, 2–3, 4–5, or 6+ times). When a selected response category included a range, consumption was coded to the midpoint. For the option of 6+ times daily, 6 was used.

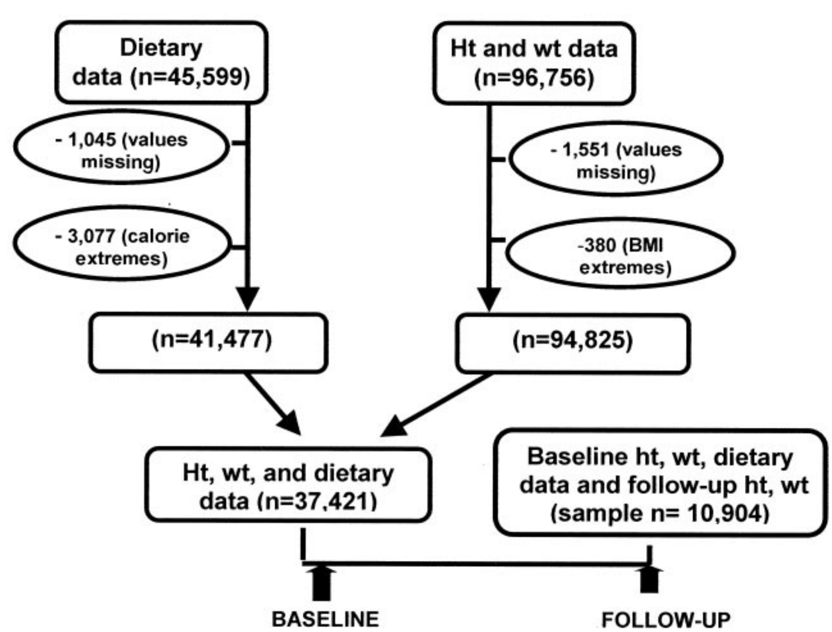


**Fig 1.** Selection of study sample: 2- and 3-year-old WIC-enrolled children: Missouri 1999–2002.

Covariates included age (in years), gender, race/ethnicity (non-Hispanic white, non-Hispanic black, other), and birth weight (in grams) as well as intake of high-fat foods (in quintiles of consumption), sweet foods (in quintiles of consumption), and total energy (in calories). Age-appropriate portion sizes were derived by Harvard University using national data (for 1985–1986) from the Continuing Survey of Food Intake by Individuals.[25] The programming and database for the calculation of total energy intake was specifically designed by Harvard using a variety of references, including the *US Department of Agriculture Nutrient Databases for Standard Reference*[26,27] and *McCance and Widdowson's The Composition of Food*.[28,29]

High-fat foods included the following items as listed on the HFFQ: ice cream, mayonnaise, potato chips, cookies, cakes, pie, chocolate, hot dogs, bologna, butter, margarine, fried chicken, fried fish, sausage, bacon, donuts, sweet rolls, and french fries.[30] Sweet foods included sweet items that were listed on the HFFQ and were not included in either the sweet drinks or high-fat foods variables: candy, Jell-O, pudding, and fruit roll-ups. Coding for the intake of high-fat foods and sweet foods was similar to that used for consumption of sweet drinks.

### Statistical Analysis

In the analysis, consumption was calculated in terms of the average number of times sweet drinks were consumed daily and categorized as follows: 0 to <1 drink/day, 1 to <2 drinks/day, 2 to <3 drinks/day, and ≥3 drinks/day. Comparisons were made between those who consumed 0 to <1 drink/day, the referent group, and those who consumed more.

We used bivariate analysis to assess the unadjusted relationship between the exposure and outcome variables and between potential confounders and the outcome variable (results not shown). We used logistic regression to adjust for potentially confounding variables using 3 different models. Model 1 included sociodemographic variables (age, gender, race/ethnicity) and birth weight only. Model 2 included dietary factors that might be associated with overweight, including the intake of high-fat foods and sweet foods, in addition to the variables of model 1. In model 3, total energy intake was added to the variables from model 2. Total energy may be a confounder if consumption of sweet drinks is a marker for other dietary factors associated with overweight, or it may be part of the causal chain between consumption of sweet drinks and overweight.

Results were stratified by 3 categories of baseline BMI. Incidence of overweight was determined among children who were normal or underweight (BMI <85th percentile) or at risk for overweight (BMI 85th–<95th percentile). We combined normal or underweight because only 5 of the 466 children who were underweight at baseline became overweight by follow-up. Persistence of overweight was determined among children who were overweight (BMI ≥95th percentile) at baseline. Statistical Analysis Software (SAS) version 8.02[31] was used for all analyses.

## RESULTS

Children who were enrolled in the Missouri WIC program and included in the sample were very similar to those who were not included in terms of gender, age, birth weight, baseline BMI, consumption of sweet drinks, and total calorie consumption (Table 1). A substantial difference was seen in race, however, between sample children and those who were excluded because they lacked food frequency data: children with no food frequency data were more likely to be black (30%) than were sample children (6%).

At baseline, 8228 (75.5%) children were normal or underweight, 1579 (14.5%) were at risk for overweight, and 1097 (10.1%) were overweight (not shown). Of children who were normal or underweight at baseline, 3.1% were overweight at follow-up; of those who were at risk, 25% were overweight at follow-up; and of those who were overweight at baseline, 67% remained overweight at follow-up (data not shown).

Daily consumption of drinks averaged 0.3 for soda, 0.7 for fruit drinks, 1.0 for vitamin C–containing juices, and 1.0 for other juices (data not shown). Total consumption of all sweet drinks averaged 2.9 drinks/day (Table 1). Eighty-eight percent of children consumed sweet drinks once or more daily, and 41% consumed these drinks at least 3 times daily (Table 2). Mean total energy intake was 1780 calories daily (Table 1). Energy intake increased as the consumption of sweet drinks increased with mean calorie consumption for those who consumed 0 to <1, 1 to <2, 2 to <3, and ≥3 drinks 1425, 1596, 1771, and 2005, respectively (data not shown).

The strength of the associations between consumption of sweet drinks and overweight at follow-up varied by baseline BMI but was similar across the 3 models (Table 3). Results for model 3, which controlled for all variables, including age; gender; race/ethnicity; birth weight; and intake of sweet foods, high-fat foods, and total energy, are presented here. Normal or underweight children who consumed 1 or more sweet drinks daily were 1.3 to 1.5 times as

**TABLE 1.** Characteristics of 2- and 3-Year-Old Children Enrolled in the Missouri WIC Program, 1999–2002

| Characteristic | Included in Study Sample | Not Included in Study Sample | |
|---|---|---|---|
| | (Height, Weight, Dietary Data, and Follow-up) | (Height, Weight, Dietary Data; No Follow-up) | (Height, Weight Data; No Dietary Data) |
| *N* | 10 904 | 26 508 | 57 413 |
| Race or ethnicity, % | | | |
| White | 88.6 | 84.6 | 59.8 |
| Black | 5.8 | 9.1 | 30.4 |
| Other | 5.6 | 6.3 | 9.8 |
| Female gender, % | 50.1 | 48.6 | 49.4 |
| Mean age, mo | 33.8 | 33.0 | 32.6 |
| Mean birth weight, g | 3300 | 3290 | 3293 |
| Baseline BMI, % | | | |
| At risk | 14.5 | 14.4 | 14.0 |
| Overweight | 10.1 | 10.2 | 10.3 |
| Consumption | | | |
| Mean sweet drinks/d | 2.9 | 3.0 | – |
| Mean cal | 1780 | 1771 | – |

**TABLE 2.** Prevalence of Consumption of Sweet Drinks by Drink Type Among Children Aged 2 and 3 Years ($n = 10\,904$)

| Drinks Per Day | Frequency of Drink Consumption, % | | | | |
|---|---|---|---|---|---|
| | Soda | Fruit Drink | Vitamin C Juice | Other Juice | All Sweet Drinks* |
| 0–<1 | 90.4 | 74.5 | 61.0 | 61.9 | 11.6 |
| 1–<2 | 7.2 | 12.5 | 17.6 | 16.8 | 26.5 |
| 2–<3 | 2.0 | 10.4 | 17.7 | 17.7 | 20.8 |
| ≥3 | 0.4 | 2.6 | 3.7 | 3.6 | 41.1 |

* Includes soda, fruit drinks, vitamin C–containing juice, and other juice.

likely to become overweight as the referent group (<1 drink daily), but these results were not statistically significant. Children who were at risk for overweight at baseline and consumed 1 to ≥3 sweet drinks daily, however, were significantly more likely to become overweight than the referent. Specifically, those who consumed 1 to <2 drinks had an adjusted odds ratio (AOR) of 2.0 (95% confidence interval [CI]: 1.3–3.2), whereas for 2 to <3 drinks and ≥3 drinks, the AORs were 2.0 (95% CI: 1.3–3.2) and 1.8 (95% CI: 1.1–2.8), respectively. Similarly, overweight children who consumed 1 to ≥3 sweet drinks daily were more likely to remain overweight; here the AORs were 2.1 (95% CI: 1.3–3.4) for 1 to <2 drinks, 2.2 (95% CI: 1.4–3.7) for 2 to <3 drinks, and 1.8 (95% CI: 1.1–2.9) for ≥3 drinks.

When sodas were excluded from the sweet drink exposure variable and model 3 was used, the association between consumption and overweight remained strongly positive and statistically significant among children who were overweight or at risk at baseline (Table 4). With fruit juice only, we found no significant associations for at-risk or normal/underweight children (odds range: 0.8–1.2). Among children who were overweight at baseline, the association with overweight was positive, although the strength was diminished (odds range: 1.3–1.5), and the results were of only borderline significance. The ORs associated with juice consumption were close to 1 for at-risk and normal or underweight children (Table 4).

## DISCUSSION

The problem of increasing overweight among children has prompted a search for factors that contribute to this trend. Our study provides evidence that the consumption of sweet drinks as infrequently as 1 to 2 times daily increases the odds of becoming overweight among those who are at risk for overweight at baseline and of remaining overweight among those who are already overweight by 60% or more. Although comparisons are limited because no other known studies provided results stratified by baseline BMI, our results support those obtained by Ludwig et al,[14] who found that increased consumption of sugar-sweetened drinks was associated with increased weight in middle school children. In contrast to the Ludwig et al study that found a dose–response effect, we found a threshold effect with the daily intake of 1 or more sweet drinks.

Our failure to find an association between the consumption of fruit juice and the incidence of overweight (among normal/underweight children or children at risk of overweight) supports the findings of Skinner et al[18,19] and Alexy et al.[20] At the same time, the positive association between fruit juice consumption and persistence of overweight that we observed may explain the association that Dennison et al[17] found in their analysis, as it is not possible to differentiate between incidence and persistence of overweight in a cross-sectional study.

The similar ORs observed in model 2, in which we controlled for the intake of high-fat and sweet foods, and model 1, in which we did not control for these foods, demonstrates that the association between consumption of sweet drinks and overweight seems to be independent of the influence of other foods that have been linked to overweight. The lack of change in the ORs from model 2 to model 3 when total caloric intake was added could indicate that total energy intake is not part of the mechanism by which consumption of sweet drinks leads to overweight or that total energy intake, as measured by the HFFQ, was not representative of true intake.

Our study has a few important strengths. The first is its longitudinal design, with data on diet, height, and weight collected at baseline and follow-up height and weight repeated 1 year later. Although the observational nature of this study precludes a determination of cause and effect, this design makes it possible for us to show that the effect on weight status followed consumption of sweet drinks. Second, the large sample of nearly 11 000 children enabled us to stratify our results by baseline BMI. Third, by adjusting for age; gender; race or ethnicity; birth weight; and intake of high-fat foods, sweet foods, and total energy, we were able to demonstrate the presence of an association between consumption of sweet drinks and overweight that seems to be independent of these factors. Finally, that the HFFQ used was validated for use in assessing nutrient intake among low-income, preschool children strengthens our assumption that the data collected are reflective of the actual intake of sweet drinks.

Our study is also subject to limitations. We were unable to control for several factors that have been positively associated with overweight, such as television viewing,[32] parental overweight,[33] and lack of breastfeeding.[34] Factors such as these or others for which we have not been able to control fully may have resulted in confounding or residual confounding of the association between sweet drink consumption and overweight. In addition, because the majority of children in the sample did not have their dietary patterns assessed using the HFFQ at their 1-year follow-up clinic visit, we used baseline intake of sweet drinks as an indicator of consumption during the follow-up period. Another limitation was the selection of a sample that included only those WIC-enrolled children who attended 1 of the primarily rural clinics that used the HFFQ during the study period. These clinics serve a higher percentage of whites than is representative of the population of Missouri. It therefore is possible that there are factors

**TABLE 3.** AOR of Overweight at Follow-up Among 3- and 4-Year-Old Children by Consumption of Sweet Drinks and Weight Status at Baseline

| Sweet Drinks Per Day* | N | Prevalence of Overweight at Follow-up, % | Model I AOR (95% CI)† | Model II AOR (95% CI)‡ | Model III AOR (95% CI)§ |
|---|---|---|---|---|---|
| Normal or underweight at baseline (BMI <85th percentile) | | | | | |
| 0–<1 | 952 | 2.3 | Referent | Referent | Referent |
| 1–<2 | 2147 | 3.4 | 1.5 (0.9–2.4) | 1.5 (0.9–2.4) | 1.5 (0.9–2.4) |
| 2–<3 | 1737 | 3.2 | 1.4 (0.8–2.4) | 1.4 (0.8–2.2) | 1.4 (0.8–2.3) |
| ≥3 | 3392 | 3.0 | 1.3 (0.8–2.1) | 1.2 (0.8–2.0) | 1.3 (0.8–2.1) |
| At risk for overweight at baseline (BMI 85th–<95th percentile) | | | | | |
| 0–<1 | 188 | 16.5 | Referent | Referent | Referent |
| 1–<2 | 432 | 25.9 | 1.8 (1.2–2.9) | 2.0 (1.3–3.2) | 2.0 (1.3–3.2) |
| 2–<3 | 328 | 27.1 | 1.9 (1.2–3.0) | 2.1 (1.3–3.4) | 2.0 (1.2–3.2) |
| ≥3 | 631 | 25.4 | 1.7 (1.1–2.7) | 1.9 (1.2–3.0) | 1.8 (1.1–2.8) |
| Overweight at baseline (BMI ≥95th percentile) | | | | | |
| 0–<1 | 124 | 54.8 | Referent | Referent | Referent |
| 1–<2 | 312 | 68.6 | 1.7 (1.1–2.7) | 2.1 (1.3–3.3) | 2.1 (1.3–3.4) |
| 2–<3 | 204 | 71.1 | 1.9 (1.2–3.0) | 2.2 (1.4–3.7) | 2.2 (1.4–3.7) |
| ≥3 | 457 | 66.7 | 1.6 (1.0–2.4) | 1.8 (1.1–2.8) | 1.8 (1.1–2.9) |

* Includes sodas, fruit drinks, vitamin C–containing juices, and other juices.
† Adjusted for age, gender, race/ethnicity, and birth weight.
‡ Adjusted for age, gender, race/ethnicity, birth weight, sweet food intake, and high-fat food intake.
§ Adjusted for age, gender, race/ethnicity, birth weight, sweet food intake, high-fat food intake, and total energy intake.

**TABLE 4.** AOR for Overweight at Follow-up by Consumption of Sweet Drinks Excluding Sodas and of Fruit Juice Only Stratified by Baseline Weight Status

| Drinks Per Day | Sweet Drinks Excluding Sodas* | | | Fruit Juices Only† | | |
|---|---|---|---|---|---|---|
| | N | Prevalence of Overweight at Follow-up, % | AOR (95% CI) | N | Prevalence of Overweight at Follow-up, % | AOR (95% CI) |
| Normal or underweight at baseline (BMI <85th percentile) | | | | | | |
| 0–<1 | 1496 | 2.6 | Referent | 2768 | 3.0 | Referent |
| 1–< 2 | 2097 | 3.4 | 1.3 (0.9–2.0) | 1815 | 3.1 | 1.1 (0.8–1.5) |
| 2–< | 1732 | 2.8 | 1.0 (0.7–1.6) | 2210 | 2.9 | 1.0 (0.7–1.4) |
| ≥3 | 2903 | 3.2 | 1.2 (0.8–1.8) | 1435 | 3.3 | 1.2 (0.8–1.7) |
| Children at risk at baseline (BMI 85th–<95th percentile) | | | | | | |
| 0–<1 | 279 | 17.9 | Referent | 573 | 23.7 | Referent |
| 1–<2 | 439 | 27.8 | 1.9 (1.3–2.7) | 345 | 27.3 | 1.1 (0.8–1.6) |
| 2–<3 | 335 | 24.8 | 1.5 (1.0–2.2) | 405 | 25.9 | 1.0 (0.7–1.4) |
| ≥3 | 526 | 26.1 | 1.6 (1.0–2.3) | 256 | 22.3 | 0.8 (0.5–1.1) |
| Children overweight at baseline (BMI ≥95th percentile) | | | | | | |
| 0–<1 | 204 | 61.8 | Referent | 390 | 62.3 | Referent |
| 1–<2 | 304 | 67.4 | 1.4 (1.0–2.1) | 259 | 70.3 | 1.5 (1.0–2.1) |
| 2–<3 | 196 | 70.4 | 1.5 (1.0–2.4) | 262 | 69.9 | 1.5 (1.1–2.2) |
| ≥3 | 393 | 66.9 | 1.3 (0.9–2.0) | 186 | 66.7 | 1.2 (0.8–1.8) |

* Includes fruit drinks, vitamin C-containing juices, and other juices.
† Includes vitamin C containing juices and other juices.

related to race/ethnicity, income, or WIC enrollment that could modify the relationship between sweet drink consumption and overweight. This may reflect a selection bias that could limit the generalizability of the results. Also, the small sample size available for some of the subgroup analysis may have compromised our ability to detect a significant association between sweet drink consumption and overweight.

A final limitation is the potential for bias when parental reports are used to assess dietary intake. Although studies among adults indicate that total energy intake tends to be underreported by many, particularly those who are obese,[35,36] little is known about parental reporting of children's intake. Results of the 2 known studies that assessed the accuracy of dietary recalls provided by parents (together with their children) present conflicting results. Fisher et al[37] found that intakes reported for children aged 4 to 11 were, overall, greater than estimated expenditure but that reporting accuracy varied as a function of the children's weight and body composition; underreporting tended to occur among heavier children. In contrast, Johnson et al[38] demonstrated that reporting accuracy for 4- and 5-year-old children was not associated with child or parental adiposity. Although such potential biases must be noted, it is important to be aware that underreporting among heavier children at baseline would likely have moved the association between sweet drinks and overweight at follow-up toward the null.

Although the exact mechanism by which the consumption of sweet drinks affects weight is unknown, results of previous studies indicate that calories that are consumed in liquid form do not fully displace those that are consumed as solids[39,40] and may, in fact, lead to increased consumption of other foods.[41] This was evident in our study as total energy intake increased further than the rise in calories with the additional sweet drinks consumed.

It has been long theorized that the increasing consumption of low-fiber, easily consumed, less satisfying foods would lead to an overconsumption of calories. Over the years, studies have shown that increased fiber content leads to a reduction in energy consumption,[42–44] particularly among those who are overweight,[45] and weight.[46] This seems to be the result of fiber-containing foods' effect on promoting satiety,[47–52] which they do by stabilizing glucose metabolism,[50,51] reducing energy density,[53,54] and reducing the rate of ingestion[55] and gastric emptying.[56]

Additional evidence suggests that although children are generally adept at responding to the energy density of their diet and regulating their intake over a 24-hour period, there are individual differences that appear as early as the preschool period. Children who are predisposed to develop a preference for energy-dense foods exert a great deal of control over their diet by eating what they like and leaving the rest. These individual eating patterns as well as a child's level of adiposity seem to affect their ability to self-regulate their intake.[57] Children with greater body fat stores seem to have greater difficulty regulating their energy intake than their normal- or underweight counterparts.[58]

Given the many negative implications of the rising rates of childhood obesity, identifying ways to reduce its prevalence has become a public health priority. Clearly, no 1 factor is entirely responsible. Addressing the problem undoubtedly will entail changes in both diet and physical activity. This study suggests that, in the case of preschool-aged children, increased consumption of sweet drinks might play an important role. Additional studies are needed to understand better the mechanism by which this consumption contributes to overweight.

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