Sugar-Sweetened Beverages and Children's Health

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Abstract

Temporal trends in the epidemic of childhood obesity have been paralleled by increases in the consumption of sugar-sweetened beverages (SSB) during childhood. Consumption has increased dramatically over the past several decades in all age ranges, with some moderation over the past 10 years. Evidence from cross-sectional, longitudinal, and interventional studies supports links between SSB consumption in childhood and unhealthy weight gain, as well as other untoward health outcomes. These data have stimulated public health efforts to curtail consumption as a means of improving childhood weight status and related health outcomes. Reducing ready access to SSBs, changing the message environment to which children are exposed, and replacing SSBs with healthier beverages have had moderate success in decreasing SSB consumption and curbing unhealthy weight gain.

INTRODUCTION

The current worldwide epidemic of childhood obesity is well documented; childhood obesity in the United States has tripled from the 1970s to 2000, and significant increases have occurred even in developing areas of the world (62, 111). In the United States, current rates of childhood overweight and obesity are 15% and 17%, respectively (110), whereas in Europe, rates vary from 6% to 27% based on the country (150). Equally well documented are the sequelae of childhood obesity, with increased risks of bone and joint problems, sleep disturbance, and psychological problems during childhood and higher risks of cancer, type 2 diabetes, and heart disease in later life (31, 69, 73, 74, 76, 84, 118). Quality of life and well-being may be significantly affected by obesity in individuals around the world. In addition, each year, the United States spends between $150 billion and $190 billion in obesity-related costs, or about 20% of all health care spending (25, 47). As the long-term risks of obesity are discovered, those in the medical and public health communities are increasingly motivated to reduce obesity rates. However, it has been difficult to document the exact causes of this epidemic of childhood overweight and obesity. The search for etiologies has been difficult because the development of childhood obesity is a multifactorial process, and contributors are related largely to common and difficult-to-measure lifestyle factors, including a lower amount of physical activity and an excess of calories ingested (58, 149).

Definitions of Sugar-Sweetened Beverages

A significant consequence of the rise in sugar availability has been the rise in consumption of beverages sweetened with added sugars, frequently referred to as sugar-sweetened beverages (SSBs) (120). SSBs encompass a wide variety of drink types, including sodas/soft drinks, juices with added sugar, Kool-Aid, sport drinks, energy drinks, and sweet tea (44, 90, 107). Trends in increased intake of SSBs are found in children (16, 146), adolescents (104, 152), and adults (27, 35, 119). These have a well-known association with dental caries (98), and research has been increasingly focused on their potential contribution to the obesity epidemic.

Although some studies have reported juice consumption alongside that of SSBs, most studies—as well as this review—consider SSBs separately from juice. Because juice comes from fruits and thus has a small amount of vitamins and a minor amount of fiber, parents may view juice as a more nutritious option (17). Juice bears some similarities to SSBs: First, simple sugar is the only predominant calorie source in juice (though some orange juice preparations have a small amount of protein as well); second, juice consumption, like SSB consumption, has been linked to a decrease in milk consumption (107, 125); and third, juice, like SSBs, has been linked to unhealthy weight gain in some (125, 146) but not all (2, 45, 126, 146) studies. Additional findings have linked juice consumption to shorter stature or poorer linear growth compared to nondrinkers (125, 146), which has not been seen in studies regarding SSBs. Some studies have suggested that juice is a gateway to SSB consumption (129), warranting at least a mention here. In this review, studies considering juice and SSBs together will be specifically noted.

Even without considering 100% juice along with SSBs, the variety of drinks considered as SSBs have varying amounts of added sugar per 12-ounce serving. These range from drinks containing 10 g of sugar, such as light sport drinks, to those containing 51 g, as in orange sodas. The relationship between SSB consumption and health can be a difficult effect to study because the calorie content of each serving size varies on the basis of the amount of sugar. This review considers studies evaluating the health sequelae of SSB consumption in childhood.

Table 1 Trends in sugar-sweetened beverages and milk consumption among US children and adolescents over time[a]

Year	Study	kcal of SSB consumed daily	kcal of milk consumed daily
1965	Nationwide Food Consumption Survey (21)	95	312
1977	Nationwide Food Consumption Survey (107)	100	250
1990	Nationwide Food Consumption Survey (107)	120	205
1996	Nationwide Food Consumption Survey (107)	180	184
2005	Nationwide Food Consumption Survey (21)	178	156
2010	National Health and Nutrition Examination Survey (100)	155	185

[a]Data are for children/adolescents ages 2–18 years from each of the Nationwide Food Consumption Surveys [1965–2005] and for children/adolescents ages 2–19 years from the National Health and Nutrition Survey [2010]. All numbers have been weighted to be nationally representative.

Trends in SSB Consumption

In 1977–1978, children in the United States consumed on average 88 kcal per day in SSBs; by 1999–2000, this number had grown to 166 kcal per day (107), as shown in a composite summary of multiple sources in **Table 1** (21, 75, 100, 107). This amount has moderated more recently; consumption in recent years has averaged ~150 kcal daily (52, 75, 100). However, this quantity remains much larger than historical levels (91). In the mid-1990s, children's intake of sugared beverages passed that of milk (21). At the current rates of consumption, each child in the United States ingests on average a total of 55,000 kcal per year in SSBs. If this amount is above the usual caloric need and not offset by decreased intake or increased metabolism, the result is an unhealthy amount of stored fat tissue. This observation supports the plausibility that SSB consumption may contribute to adverse childhood health on an epidemiologic basis.

SSB consumption differs significantly by age range. Multiple investigators have documented consumption beginning at young ages, including reports by Park that 25% of children studied consumed SSBs during infancy in a cohort of 1,189 US children (112), and these children had a higher likelihood of consuming SSBs at 6 years of age (115). In an analysis of NHANES data from 2007 to 2010, 62% of preschool children ages 2–5 years consumed SSBs daily compared with 73% of children ages 6–11 years and 76% of adolescents ages 12–19 years (15). A gradual rise in SSB calories consumed by age was also noted among SSB drinkers: Children ages 2–5 years consumed 127–139 kcal per day, children ages 6–11 years consumed 176–220 kcal per day, and those ages 12–19 consumed 290–298 kcal per day (15). These data showing higher consumption at later age ranges may have bearing on the timing of any intervention to discourage consumption early and prevent initiation of consumption.

SSB consumption also varies by racial/ethnic group. At the younger age range of 2–5 years, African American children consume the highest amount of SSBs, followed by Hispanic and white and Asian children (15, 32), whereas among adolescents 12–19 years old, white children consume the largest number of calories, followed by Hispanics and African Americans and Asians. There are also differences in SSB consumption by socioeconomic status (SES). For example, in a cohort of children followed from ages 2 to 5 years, 16–23% of children in the lowest SES quintile consumed SSBs daily compared with 4% in the highest SES quintile (32).

HEALTH EFFECTS

SSBs and Unhealthy Body Weight Status

Most of the investigation into SSB consumption has focused on the relationship with unhealthy weight status, including a higher body mass index (BMI) and a higher amount of adipose tissue compared to nondrinkers. Our understanding of these connections has been informed through the use of multiple approaches that we now consider here in the order of increasing strength of the study designs involved.

Cross-sectional studies. Cross-sectional studies examining the relationship between SSB consumption and weight status cannot determine causality but may provide useful information on relationships. Results from efforts to determine cross-sectional relationships have been mixed, although direct associations have been noted in multiple age groups (96).

Ariza et al. (5) found both that Hispanic American children ages 5–6 years who drank SSBs had an odds ratio (OR) of obesity of 3.7 and that overweight children in the cohort were more likely to be SSB drinkers. In an analysis of 8,500 US preschool children, using linear regression we found significant relationships between the number of servings of SSBs and the BMI *z*-score of the children at both 4 and 5 years of age (32), as well as higher odds of overweight (at age 4) and obesity (at age 5) even after adjustment for confounding variables, including sex, SES, and race/ethnicity. In a wider age group, Grimes et al. (60) found in a large cohort of Australian children ages 2–16 years that those drinking SSBs were more likely to be overweight. Nicklas et al. (106) evaluated children from the Bogalusa Heart Study at age 10 years and found an OR for overweight of 1.33 for SSB drinkers versus nondrinkers. Berkey et al. (12) found in 9-year-old and 14-year-old girls (but not boys) a linear relationship between the amount of SSBs consumed and BMI.

Nevertheless, not all cross-sectional studies have demonstrated these relationships. Among younger children, O'Connor et al. (109) evaluated data from 1,160 children ages 2–5 years in the 1999–2003 NHANES and found that even though children drinking >12 ounces daily of SSB had higher total daily caloric intake, their BMIs were similar as seen in nondrinkers. Keller et al. (71) noted that among a small cohort of children ages 3–7 years, those drinking SSB were not more likely to have a higher BMI. Forshee et al. (54) did not find any difference in BMI according to SSB intake in a large cohort of children ages 6–19 years. Although it is not mentioned in these reports, the potential for errors in reported caloric intake is a possible explanation for these findings.

The potential for SSBs to affect weight depends on whether consumption of calories from SSBs is above an individual's usual caloric intake (and is not offset by a compensatory decrease in intake of calories from other sources or by an increase in energy expenditure). Increased consumption beyond energy expenditure would be expected to result in weight gain. O'Connor et al. (109) determined that children who drank >12 ounces daily of SSBs had a higher total daily caloric intake than did nondrinkers; however, total energy expenditure was not assessed. Other studies found that children who drank SSBs were less likely to drink milk than were those who did not drink SSBs, which suggests a compensatory decrease in another calorie source, as well (32, 71, 89). However, changes in consumption of healthier sources of calories also highlight the potential for other mechanisms of untoward health effects of SSBs, such as the potential for a lower intake of protein and calcium among SSB drinkers if milk intake were to decrease.

Longitudinal studies. Longitudinal study designs have the advantage over cross-sectional studies in that they can potentially identify associations between SSB consumption and changes in weight status over time, although as with cross-sectional studies, confounding effects of unmeasured or

unaccounted for variables that affect both SSB consumption and unhealthy weight gain cannot be ruled out. As with cross-sectional studies, longitudinal studies have had mixed results regarding change in weight over time in association with SSB intake.

Dubois (38) found in an analysis adjusted for SES factors that children who drank SSB between the ages of 2.5–4.5 years (compared with nondrinkers of SSBs) had an OR of 2.4 for being overweight at age 4.5 years. We found that in analyzing data from children followed between ages 2 and 5 years that those consuming ≥1 SSB serving daily (compared with those drinking less) had a greater change in BMI *z*-score and were more likely over the next 2 years to become overweight and obese (32). Pan et al. (112) determined that SSB consumption during infancy (compared with no consumption) carried an OR of 1.71 for obesity at age 6 years. These infants consuming SSBs had an OR of 2.2 for also consuming SSBs at age 6 years, providing a potential link to increased long-term consumption contributing to greater weight gain (6). Berkey et al. (12) found that children who were 9- and 14 years old who increased their SSB consumption (versus those who did not) demonstrated higher gains in BMI. Finally, a meta-analysis of longitudinal studies by Te Morenga et al. (135) evaluated 22 studies that analyzed risk of overweight between children consuming ≥1 serving of SSBs daily (or juice, in the case of 3 studies) versus none. They found an OR of 1.55 (confidence interval 1.32, 1.82) for higher gains in BMI among SSB drinkers over time.

Again, not all longitudinal studies have demonstrated significant associations between SSB consumption and higher weight gain. Laurson et al. (85) followed a cohort of 10-year-old children for 18 months and found no association between SSB consumption and weight gain. Forshee et al. (53) performed a meta-analysis of 12 longitudinal studies among children ages 2–19 years old and reported no significant association between SSB consumption and weight gain. Malik et al. (97) recalculated Forshee's meta-analysis using scaling techniques for studies that had reported BMI differences associated with 1-ounce increments in SSB intake and reported that the same studies demonstrated a positive association.

Intervention studies. To provide better evidence of a direct causal link between SSBs and unhealthy weight gain in childhood, intervention studies have focused on evaluating weight-related differences between children and adolescents randomized to consume either SSBs or noncaloric alternatives. In each case presented here, the researchers chose to recruit children who consume SSBs regularly because of the ethical problem with randomizing a non-SSB-consuming child to begin drinking SSBs and potentially incur long-term weight gain. These studies provided the noncaloric alternatives for free, in either a blinded or unblinded manner. They are important because they yield direct scientific evidence about the effects of removing SSBs as a means of altering weight status. However, because the noncaloric drinks were provided for free, it is less clear from these studies how effective a public health strategy would be to merely recommend changing to noncaloric beverages without providing a similar financial incentive.

Ebbeling et al. (39) performed both a pilot study and a larger-scale trial of randomizing adolescents either to receive no intervention or to have noncaloric beverages delivered weekly to their homes, with the instructions to consume these beverages instead of SSBs. In the case of their pilot study, they found that after 25 weeks of intervention, there was no overall difference in BMI between those who were randomized to continue drinking SSBs compared with those who had noncaloric drinks delivered to their homes. However, they did find that among those in the highest BMI tertile that the replacement of SSBs resulted in a lower BMI after 25 weeks. This result may have some implications that SSB consumption contributes more strongly to weight gain in individuals who are more predisposed to higher weight status (39).

The same research group followed this study with a larger-scale trial that randomized 224 adolescents with a mean age of 15 years to a similar intervention over a 12-month period, which was

followed by 12 months of continued assessment without the provision of noncaloric replacements (40). They reported that after one year adolescents randomized to receive noncaloric beverages delivered to their homes (versus continuing with usual SSB consumption) gained significantly less weight (+1.6 versus +3.5 kg, $p = 0.04$) and BMI (+0.06 versus +0.63). After two years (the second year without treatment), these changes did not persist ($p = 0.06$). The effect of SSB consumption on weight gain at one year was more significant among Hispanic adolescents, suggesting cultural or racial/ethnic differences. The authors did not report whether baseline SSB consumption was higher in Hispanic adolescents compared with other groups; if this was the case, it may have affected the amount of weight gain over the course of the study.

The research group of de Ruyter et al. (30) also tested the effects of replacing SSBs with noncaloric beverages in a randomized fashion but did so with three important differences from the studies cited above. First, the trial was double-blinded, with similarly appearing and similarly tasting beverages (although a greater proportion of children in the noncaloric group correctly guessed their treatment group, presumably based on taste). Second, the intervention was among younger children ages 4–11. And third, the drinks were delivered through the child's school, allowing teachers to observe consumption directly (though additional drinks were provided for home consumption). Children randomized to have school-based delivery of noncaloric drinks (versus similar SSB in a blinded fashion) by 18 months gained less: lower BMI z-score (+0.02 versus +0.15%, $p = 0.001$), as well as a smaller waist circumference (+3.4 cm versus +4.1, $p = 0.01$) and lower fat percentages (with 43% less fat as measured by skinfolds). These children were given drinks to take home on weekends, but their home consumption of SSBs was otherwise unaltered.

From a research standpoint, these studies demonstrate that removal of calories from SSBs is effective at the end of such replacement at reducing the change in BMI z-score relative to controls. However, as discussed further below, intervention on a societal level will require different strategies to reduce SSB consumption.

Other Health-Related Effects

Although most of the investigation into SSB consumption has focused on its relationship to unhealthy weight, there have been more limited analyses of other potential relationships. The earliest recognized adverse health outcome was the association between the growing presence of SSB and of dental caries (13, 98, 113, 117). These associations have led the American Dental Association to recommend against SSB consumption. SSB consumption in childhood has also been linked to earlier timing of puberty (140) and higher blood pressure (105). Higher weight gain is also linked to earlier puberty in girls (70) and higher blood pressure (8); thus, it is possible, or likely, that these relationships are mediated, in part, by the effects of SSBs on unhealthy weight gain. Reported associations of poor sleep with soda consumption may be related to calories, weight gain, caffeine content, or other lifestyle factors that may be more challenging to measure (55).

One recent study examined SSBs and self-reported hyperactivity/inattention symptoms in 1,649 middle school students (123). For each SSB consumed, the risk of hyperactivity/inattention symptoms increased by 14%. After controlling for possible confounders, students reporting drinking energy drinks were 66% more likely to also report hyperactivity/inattention. This association study needs to be repeated with other research methods but certainly raises striking associations that should be followed closely.

Among adults, SSB consumption has been linked to the risk of metabolic syndrome (95), diabetes (95), and cardiovascular disease (94), implicating SSBs in other important health effects that may require a longer exposure to SSBs than seen during childhood.

STRATEGIES TO REDUCE SSB INTAKE

Successful obesity-reduction programs are multifaceted. There is no single cause for obesity, and there will be no single cure. Programs that target physical activity, lifestyle, health, and nutrition for individuals within families and social contexts are likely to have the most success (50, 51). The global obesity epidemic indicates that many children worldwide consume more calories than they need (62). Within nutrition, the obesity epidemic cannot be attributed to one single food source. That said, SSBs as a single food group represent the largest source of sugar in the American diet (63) and are a target for reduction efforts.

Institute of Medicine Report on Obesity Prevention

In a comprehensive report entitled "Accelerating Progress in Obesity Prevention: Solving the Weight of the Nation," the Institute of Medicine made recommendations and provided strategies and action steps to accelerate progress in preventing obesity (68). The report identifies five goals:

1. Make physical activity an integral and routine part of life;
2. Create food and beverage environments that ensure that healthy food and beverage options are the routine, easy choice;
3. Transform messages about physical activity and nutrition;
4. Expand the role of health care providers, insurers, and employers in obesity prevention; and
5. Make schools a national focal point for obesity prevention.

Within these goals are recommendations and strategies to promote action. Under goal 2, the authors recommend adopting policies to reduce overconsumption of SSBs, increasing the availability of lower-calorie beverages in restaurants, and using strong nutritional standards for beverages sold or provided through the governmental subsidies such as school lunch programs or supplemental nutrition programs. Studies that relate to these strategies are discussed below. Goal 3 discusses social marketing, marketing standards, and education as means for promoting healthy weight. The report discusses ways that industry, educators, and governments can act to create information environments that surround people with messages about healthful physical activity, food, and nutrition behaviors. Examples related to SSBs are provided below, including examples about health care visits and schools (goals 4 and 5).

Environmental change interventions that may influence SSB consumption have generally targeted SSB availability in schools, stores, and public places, as well as advertising that targets children (28, 116, 136, 151). However, the greatest consumption of SSBs for children and adults happens in the home. Targeting home consumption is, therefore, a key strategy as well (24, 30, 40, 143). Researchers and policy makers have examined several approaches to reducing individual SSB consumption, including helping individuals avoid SSBs, reducing portion sizes, providing education about healthy nutrition, and reaching families through pediatricians with messages for the home. These approaches are discussed below (see **Table 2**). Additionally, several larger-context policy strategies may be helpful in curbing SSB intake.

Behavioral Settings

Ensure ready access to drinking water. Water is essential to life, and while fluid can be obtained from various sources, water is the simplest calorie-free, healthful drink. Of note, in contrast with SSBs, which promote the development of dental caries, drinking water that has been fluoridated has been key for preventing dental caries, which are an extremely prevalent chronic disease in children in the United States and around the world; sufficient intake of water and fluoride is

Table 2 Strategies to reduce consumption of sugar-sweetened beverages

	Intervention	Examples	References
Behavioral settings	Ensure water access	Water fountains, water bottle refilling	41, 42, 116
	Limit access to SSBs	Vending machines, portion sizes	37, 81, 133, 145
	Promote alternatives	Healthier snacks, calorie-free beverages	151, 154, 155
	Education	Screening, counseling, technology, physician discussion	83, 124, 128
Government policies and industry practices	Marketing/advertising	Limit cartoons in advertising, limit advertising during children's programs, set nutrition parameters for what can be advertised	20, 80, 99, 132
	Taxes	Taxes per drink, per ounce, borne by producer or consumer	21, 23, 108, 138
	SNAP/WIC	Limit which beverages can be purchased with government subsidies	4, 79

Abbreviations: SNAP, Supplemental Nutrition Assistance Program; WIC, Women, Infants and Children.

necessary during childhood (26). Studies show that those who drink more water drink fewer other beverages (67) and consume fewer calories from beverages (100), potentially saving calories and money (if public water sources are used). Environmental issues are raised with respect to the use of disposable plastic bottles (131). Installing water fountains and water bottle refilling stations in public areas increases water usage (41). Distribution of reusable water bottles can motivate increased water drinking (42, 116).

In a study in Mexico, replacing SSBs with water (delivered biweekly to the home) reduced triglycerides and the prevalence of metabolic syndrome after nine months in obese women (65). In a small study ($N = 22$) out of rural Michigan, adolescents were screened about their SSB consumption in the past 24 hours using smart phone technology during a clinic visit. They were then given information via oral advice and a pamphlet about SSBs and encouraged to drink water and use a water bottle. After 30 days, follow-up showed significantly decreased SSB consumption in the intervention group (33). During the "Trinkfit" study in Germany, teachers taught students about water consumption, and water fountains and water bottles were made readily available in elementary schools. The researchers found that children in the intervention group drank one more glass of water per day but did not have differences in juice or soda consumption. After one year, the risk of overweight was lower in the intervention group (101).

Limit Access to Sugar-Sweetened Beverages

Schools that have vending machines provide greater access to SSBs and unhealthy snacks than schools that do not (81). Schools vary widely in the availability of vending machines with SSBs (1); a focus on limiting access to SSBs may represent an important opportunity for those schools that do have vending machines and advertising to make a change (102). A study in Minnesota found that access to low-nutrient, energy-dense beverages and snacks decreased from 2002 to 2008 (81). One school found that implementing policies based on guidelines in Canada resulted in the reduction of SSBs and unhealthy foods and wider access to fruits, vegetables, and physical activity (145). However, another study found that students who had in-school access to vending machines had fewer servings of soda and fast food during the week from other sources, indicating

that the school food environment is only one of several to which students are exposed throughout the week (133). An observational study of children from across the United States found that weight gain between fifth and eighth grade was not related to exposure to the sale of unhealthy foods in school at that time, indicating that other factors may be involved (139).

Promote access to and consumption of more healthful alternatives to SSBs. Several researchers and public health advocates have promoted the replacement of SSBs with more healthful options. A recent study (151) in New South Wales, Australia, promoted healthier food options in recreational sporting clubs by having clubs in the study assigned to the intervention arm offer at least 6 fruits and vegetables for sale and to ensure that at least 75% of nonalcoholic drinks in the canteen refrigerator were non-SSBs and were positioned in the upper half of the fridge. The canteens offered meal deals where a fruit or vegetable and water were included as a package with the main course at a reduced price, and pricing strategies ensured that fruits, vegetables, and non-sugar-sweetened drinks were priced competitively compared with less healthy products. Signs and coaches were available to help people make decisions. This community intervention did result in the purchase of fewer SSBs and greater consumption of healthier options. One study that followed 9-year-old children for 6 years in Denmark estimated that replacing SSBs with water or milk was inversely associated with body fatness (155). The Supermarket Healthy Eating for Life study conducted a randomized trial over three months with four arms: skill building in making healthy shopping choices and menu choices, including drinking more water and balancing toward healthier foods and beverages; price reduction in stores for healthier options; both of the above interventions; and the control group. The authors found that both were helpful in the short term for increasing the purchase of fruits and vegetables, but neither changed beverage purchasing patterns, demonstrating the challenges of changing food and drink behavior patterns (7).

Education: Screening and counseling about SSB consumption. Another way researchers and public health advocates have sought to reach children and families with messages about SSBs is through pediatricians (14, 36, 147). Because many children regularly visit their primary care provider throughout childhood, starting shortly after birth, this channel may be a good way to provide information and education to families about obesity prevention and treatment strategies (147). Some studies have suggested routine screening for SSB use (as might be done for tobacco use) during medical visits. Technology could be employed to make screening rapid and simple (103, 124, 127). Other efforts have sought to expand the knowledge and skills of medical care providers to conduct nutrition screening and counseling regarding SSB consumption. The pediatric visit presents a unique opportunity to reach youth with messages about health (83, 134). Providing education and counseling to families may be a helpful way to reduce SSB intake (83, 130, 134), although a person's knowledge about a subject does not always predict behavior (114).

In addition to counseling, there has been an increasing effort to provide consumers with more information about the nutritional composition of what they are consuming. Starting with labeling ingredients and calories on food packages, all beverages sold in individual containers contain calorie information, as well as information about fats and sugars in the Nutrition Facts panel (141). Additionally, beginning with laws in New York City, calorie information in restaurants and fast-food locations is often displayed up on the menu or next to the foods or beverages available for purchase (48, 59). This new approach may be helpful in providing more information to consumers and raising awareness of the high caloric content of many beverages for sale in restaurant chains (18, 28, 66, 153). The US Food and Drug Administration has released a statement requiring chain restaurants to provide nutrition labeling by December 2016 (49).

Government, Policies, and Industry Practices

In addition to reaching children and individual families in behavioral settings, public health workers, policy makers, and researchers have sought the most effective ways to bring about change on a broader scale using a variety of approaches. Beverage companies are responsible to shareholders to increase profits and therefore are less likely to do things voluntarily that would limit sales, even if doing so is healthier for consumers. Voluntary industry action to promote health can have its benefits, but mandatory interventions may be necessary (47). Thus, several public policy measures have been discussed or implemented in recent years to promote the health of the public on a larger scale.

Message Environment

Strategies such as pricing healthier foods and drinks more competitively and picturing more healthy foods on the signs in restaurants may also be helpful (9). In the Institute of Medicine report discussed above, the study committee advocates for a transformation in the environment that surrounds Americans. They suggest the use of social marketing for physical activity and nutrition messages to promote awareness of healthy choices. The committee recommends targeted, age-specific, culturally appropriate messages about behavior change and environments. They also suggest implementing standards for marketing beverages to children and adolescents; ensuring consistent nutritional labeling on packages, store shelves, menus, and menu boards; and adopting consistent nutrition education policies for federal programs.

Limit marketing of SSBs and minimize marketing's impact on children. Advertising is increasingly ubiquitous. Children and youth are exposed to advertising from not only television, but also billboards, magazines, signs in stores and public places such as airports and subway stations, and now increasingly on technology such as iPad apps, video games, email, and phones. Advertising has been shown to be effective in influencing children's preferences (19, 93), and certainly the money spent by the beverage industry in advertising indicates that it is extremely effective. One study found that 97.8% and 89.4% of food-product advertisements viewed by children 2–11 years old and adolescents 12–17 years old, respectively, marketed foods that were high in fat, sugar, or sodium (121). One study found that the higher the percentage of outdoor advertisements for beverages in a census tract, the greater the odds of obesity in its residents (88). According to the Federal Trade Commission in 2009, advertisers spent the most on marketing SSBs to teenagers (56, 82). Even when fast-food chains advertise healthy foods, the outcome is that children prefer fast food, not healthy food (20). Public Health advocates have called for advertising that targets children and youth to follow certain principles (132): The Sydney Principles were developed by an International Obesity Taskforce (IOTF) Working Group to provide guidance. The Principles state that actions to reduce marketing to children should: (*a*) support the rights of children; (*b*) afford substantial protection to children; (*c*) be statutory in nature; (*d*) take a wide definition of commercial promotions; (*e*) guarantee commercial-free childhood settings; (*f*) include cross-border media; and (*g*) be evaluated, monitored, and enforced (132, 148). Public health researchers and advocates have continued to monitor how well marketing and advertising follow these principles and have indicated that there is still room for improvement (72, 80, 99). Of note, after significant advocacy in this arena, advertisements for SSBs have decreased in recent years, although rates still remain very high for children from low socioeconomic backgrounds and certain racial/ethnic groups (64, 136).

Conversely, many cities and nations have taken to using advertising to promote health messages (social marketing) as well as to "counter-market" or demarket unhealthy products. For

Figure 1

Policy to increase awareness. Example of public health messaging attempts to reduce the consumption of sugar-sweetened beverages in New York City.

example, New York City launched extensive awareness campaigns in the subways to highlight the health effects of added sugar from SSBs (see **Figure 1**; **Figure 2** is an example from Australia). As an example of social marketing, the Let's Move Campaign from US First Lady Michelle Obama includes the Drink Up component to promote water as the healthiest beverage alternative (**http://www.letsmove.gov/drink-lots-water**).

Taxes. In 1776, in *The Wealth of Nations*, Adam Smith wrote, "Sugar, rum, and tobacco are commodities which are nowhere necessaries of life, which are become objects of almost universal consumption, and which are therefore extremely proper subjects of taxation" (87).

Past experience shows that the consumption of many items varies on the basis of price. Taxes and higher prices for cigarettes consistently reduce consumption (23, 86, 122). Similarly, when taxes are placed on alcohol, consumption decreases (142). Economists and others in academia discuss the validity of government intervention when "market failures" do not promote safe, healthy production and consumption of foods (21), and they recommend the use of fiscal policies to promote healthy eating via differential food pricing (138).

Brownell and colleagues (21) provide a helpful discussion of the context in which instituting beverage taxation policies can be useful. First, many people make decisions about food and

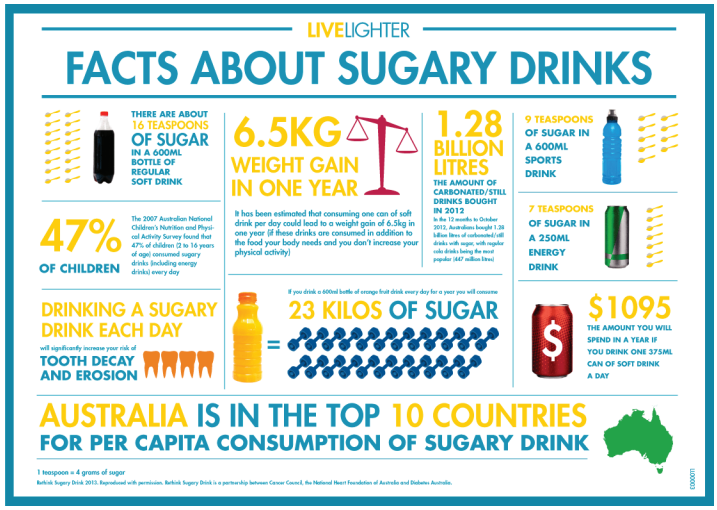

Figure 2

Global drive. SSB education materials from Australia.

beverage consumption without knowledge of the future implications and outcomes. This behavior can be further complicated by the food and beverage industry's extensive marketing, which works very hard to convince the public of the benefits of their products. Second, Brownell discusses time-inconsistent preferences. Many people, and especially children and adolescents, make decisions on the basis of the present without significant regard for future consequences. A third context that affects beverage consumption and policy acknowledges that the consumer does not bear the whole cost of the choice. Obesity costs are rising, and recent estimates state that medical costs are more than $150 billion for obesity-related illness. About half of these costs are covered by public spending in the form of Medicare and Medicaid (50). The producers of the sugared beverages, as well as the consumers, do not bear all the medical costs of obesity and the glucose intolerance and heart disease that may accompany a high-calorie diet.

Although some beverage tax opponents are concerned that taxes on beverages would selectively disadvantage the poor (regressive taxes), many public health concerns such as poor nutrition, diabetes, obesity, and related morbidities are also more common among people of lower incomes (51). For an overview of various types of public health nutrition taxation and the research behind them, see the appendix to the manuscript by Thow and colleagues (138). A penny-per-ounce tax on SSBs may reduce consumption by more than 10% (22). It is difficult to produce behavior change of that magnitude using education alone.

In 2012 and 2013, three US cities attempted taxes on sugary drinks. In all three locations, the proposals failed during voting (108). A recent analysis of news coverage during that time found that protax arguments came mostly from city officials and public health advocates (108). A wide variety of people argued against the tax. The soda industry was found to be absent from news coverage. The media did not acknowledge when antitax arguments and groups were funded by the soda industry. Nixon and colleagues (108) note the similarities in the way the tobacco industry fought regulation. In March 2015, Berkeley, California, passed the first US excise tax of one cent per ounce of SSB, resulting in increased prices of SSBs compared with those sold in Oakland and San Francisco, whereas nontaxed beverages had no such price increases (46).

Taxes may also serve to educate the public (137, 138). When a tax on a good comes into public view for debate, there is an opportunity to provide public health education about why the tax

is being proposed. Beverage companies argue that education about nutrition, rather than taxes, should be promoted. Education efforts have not historically been able to compete with commercial advertising (e.g., the over $2 billion spent in advertising by Coca Cola and PepsiCo in 2008) (29).

Government nutrition assistance programs. Federal nutrition assistance programs that provide or allow purchases of SSBs have come under scrutiny out of concern that they may inadvertently encourage children to consume SSBs. Several studies have found that infants participating in the Women, Infants, and Children's nutrition programs were less likely to be breastfed or consume vegetables than were infants not participating in these programs, but they were more likely to consume juice and SSBs (34, 78, 144). Families participating in federal nutrition programs nationwide were more likely to have unhealthy grocery store purchases than were families who did not participate; the article estimates that the Supplemental Nutrition Assistance Program (SNAP) paid at least $1.7 billion to $2.1 billion annually for SSBs purchased in grocery stores (3). Public health policy has been looking into how to change these programs to give more emphasis to healthier options (4, 79), and this remains a promising area for intervention.

GLOBAL CONSIDERATIONS

Over time, impressive changes have been made in the global food supply, leading to the greatest availability of edible oils, sweeteners, and meats in history to date (10). The rise of available sugar has paralleled the increase in BMI in the developing world. There has been an impressive global increase in the consumption of low-nutrition foods, such as SSBs and packaged, processed snack foods, in recent decades (11). Historically, when safe drinking water was not readily available, beverage companies have marketed their products as safe alternatives, and in many places today, soft drinks remain a safer alternative. In places where medical care and education are difficult to find, Coca-Cola products can be found. Some advocates of public health are looking at ways to leverage this far-reaching influence to combine with medical care in remote areas to reach children in need (43, 61).

Basu (10) finds, in analyzing food supply and economics, that much of the increased availability of SSBs and processed foods in packages can be attributed to just a few multinational corporations who have domestic production in many nations. Sales of SSBs have remained very high in North America and Latin America and are increasing in Eastern Europe and the Middle East. In the United States, there has been a slight trend toward lower-calorie or no-calorie beverages as a proportion of total bottled beverages sold, whereas in more emerging markets, energy-dense beverages are on the increase (77). Although SSB consumption has been static or decreasing in several high-income countries, per capita consumption in low- and middle-income countries has been growing: Data from 2012 from Coca-Cola show the world average consumption levels to be 94 portions per person per year (57, 92). Levels in many low- and middle-income countries are lower, at 14 portions per person per year in India, 16 in Indonesia, 21 in Pakistan, and 39 in Kenya and China. In countries with more developed economies, consumption levels are higher: 65 portions per person per year in Egypt, 79 in Russia, 99 in South Korea, 113 in Thailand, and 131 in the Philippines. Coca-Cola's market for SSBs was highest in Central and South America: 219 portions per person per year in Peru, 263 in Bolivia, 416 in Panama, 486 in Chile, and 745 for the world leader, Mexico (92).

CONCLUSION

A continually growing amount of evidence links SSB consumption during childhood to unhealthy weight gain, itself linked to multiple health issues in later life. This evidence has driven policy and

research to seek ways to curtail SSB consumption on a large scale. Successful obesity-reduction programs will be multifaceted, and no single strategy is likely to significantly reduce childhood obesity alone. However, given the relationships between sugar-sweetened beverage intake and excess weight gain, interventions to reduce consumption in early childhood and the school years, spanning the full range described above, seem reasonable targets to promote health. Recent decreases in the amount of SSBs consumed in the United States may speak to some of these emphases; however, intake remains near historic highs and worldwide SSB intake may be increasing. Continued efforts at reducing availability and intake of SSBs may be one way to address the current obesity epidemic. Overall, consumption of water can be strongly recommended as a healthier option.

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